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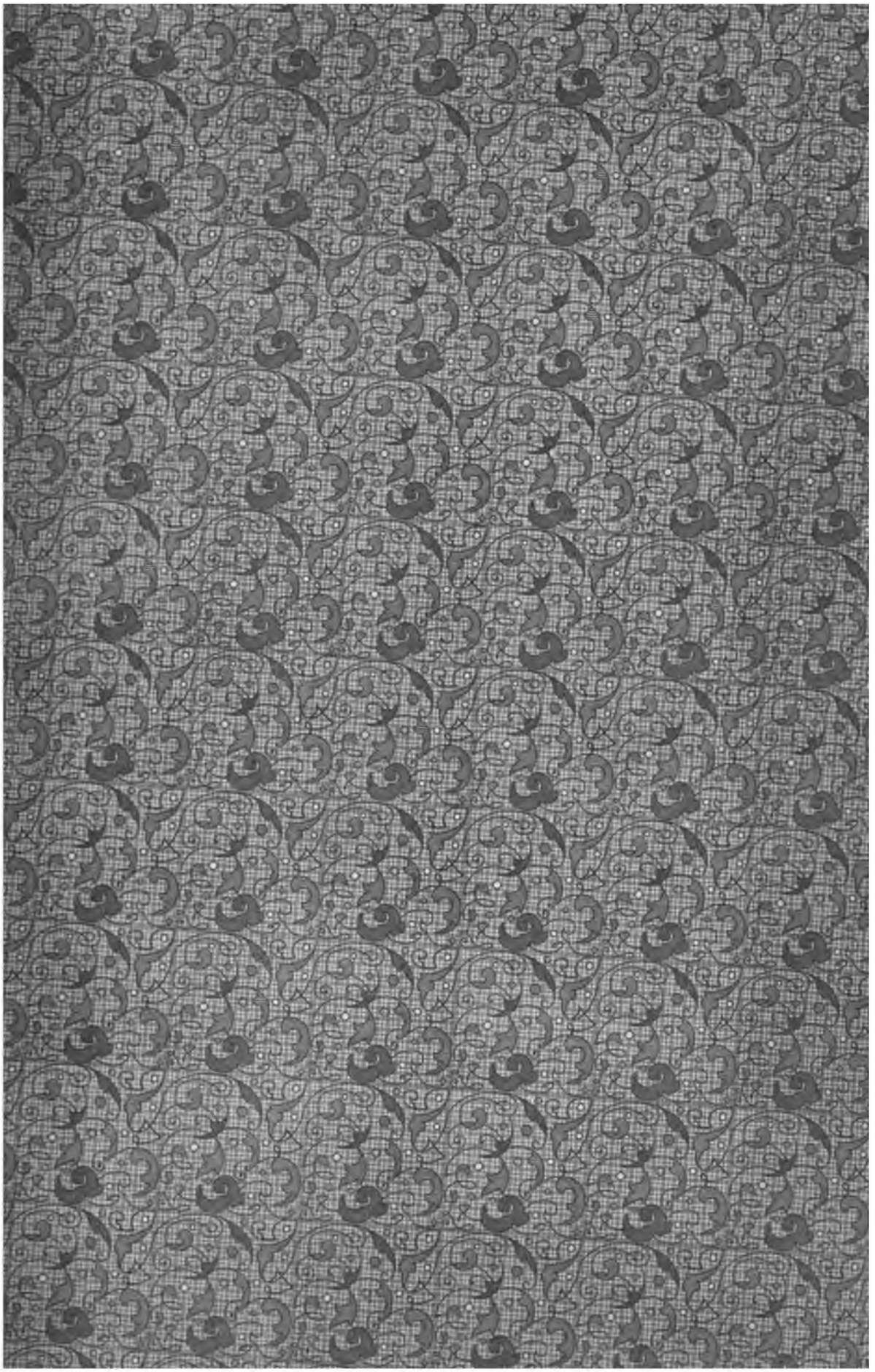

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THE

TOPOGRAPHY AND GEOLOGY

OF

SOUTH-EASTERN SINAI

ENTRY TO WADI NASB RAVINE

SURVEY DEPARTMENT, EGYPT.

THE

TOPOGRAPHY AND GEOLOGY

OF THE

PENINSULA OF SINAI

(SOUTH-EASTERN PORTION)

By

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THE

TOPOGRAPHY AND GEOLOGY OF EASTERN SINAI.

I. TOPOGRAPHY.

CHAPTER I.

INTRODUCTORY.

The Peninsula of Sinai has been justly described by Captain H. S. Palmer as follows:— (Ordnance Survey of Peninsula of Sinai, Part I, Chapter 1, p. 17) "The Peninsula of Sinai, or at any rate the greater part of it, is in reality one of the most mountainous and intricate regions on the face of the earth: sand is a feature seldom met with, plains are rather the exception than the rule, the roads are often steep and rugged, and wind for the most part through a labyrinth of narrow rock-bound valleys. It is a desert, certainly, in the fullest sense of the word, but a desert of rock, gravel, and boulder, of gaunt peaks, dreary ridges, and arid valleys and plateaux, the whole forming a scene of stern desolation which fully merits its description as the 'great and terrible wilderness.' So far from there being nothing to survey, the topographer may well shrink from the task of delineating its countless 'intricacies.'" Yet here and there, where after sudden thunderstorms the storm-waters rush down the main valleys, are found some fertile spots, oases of palms, seyal trees and rushes, producing pictures full of life and beauty in the midst of the stern hills that surround them. Perennial streams run down the wadis* of Kyd, Hebran and Isla, in the latter valley forming a small waterfall whose sides are covered with maiden-hair fern; groves of tamarisk and palm fill the upper portions of Nasb gorge; while at Dahab and Nebk the latter fringe the coast-line at the points where the two great drainages of Nasb and Kyd enter the Gulf of Akaba. Nevertheless these occurrences are rare, and in many places, as near Ras Mohammed and in the schistose hills south of Dahab, unmitigated desolation holds sway.

* Wadi is the Arabic name for a valley, Jebel or Gebel for a hill.

The portion of Eastern Sinai considered in this memoir extends from Ain-el-Hudera in latitude 29° N. to the southern end of the peninsula at Ras Mohammed, the part most particularly studied and mapped in detail being the triangular area bounded on the north by the transverse range, and to the east and south by the Gulf of Akaba and the Red Sea. This isolated position behind rugged mountain-barriers traversed only by passes, themselves not especially easy, is of itself a reason why this region has been so largely neglected, while in addition, it is at a considerable distance from Suez and Tor, the only ports of the peninsula. Thus it requires a six days' journey from Suez to the Shelala Pass, which is the gate of the south-eastern triangle, the same point being reached from Tor in four days, and then only after passing over the steep and boulder-strewn col at the head of the Tarfa valley.

The early history of Eastern Sinai is wrapped in obscurity, though many writers believe that the Israelites on leaving Sinai marched to the two famous wells of Wadi-el-Ain and Ain-el-Hudera, their second station, that of Hazeroth, being somewhere in their neighbourhood. Be that as it may, the presence of numerous stone circles of very varied form and often placed in most unexpected localities, shows that man was at one time far more widely distributed in the region than he is at present, over thirty perfectly circular stone-circles being sometimes placed close together on a single gravel terrace. That these must be of very ancient date is proved by the occurrence of Nabathean (Idumean) inscriptions on some of these buildings at the foot of Abu Mesud, but there is at present no evidence in support of the suggestion made by Mr. Holland, that they may have owed their origin to the Amalekites. With these exceptions, the records are silent, no Egyptian inscriptions having been met with in Eastern Sinai,* and all traces of a Roman occupation being absent, although the peninsula was annexed to the Roman empire by Cornelius Palma, prefect of Syria. The Nabatheans were a people from the north-east, who took possession of the commercial route abandoned by the Phœnicians, and from the famous rocky city of Petra commanded the peninsula down to about the period of the birth of Christ.†

Only with the growth of the monastic principle among the early Christians in the fourth century did this wilderness again become peopled with hermits, who could in these mountain fastnesses find the solitude they sought, and who have left the traces of their presence in

* These in Western Sinai have been frequently described and figured.

† Baedeker's Lower Egypt, 1895, p. 236.

the rectangular stone buildings, generally low-doored and roofless, which are situated in the most out-of-the-way localities.

These isolated outposts were particularly subject to the inroads of the wild tribes of these mountainous regions, the Saracens and Blemmyes having on several occasions carried out massacres on a large scale, while after the rise of the Moslem power, the mountaineers seem to have made an easy transition to the new religion, and to-day the Sinai Convent alone remains as an interesting relic of the prevalence of monasticism in the peninsula. Although the eastern mountain region thus early ceases to play any part in the historical record, the Gulf of Akaba has at many periods been the successful rival of the Gulf of Suez, being the principal waterway not only for the fleets of Solomon and Ahab, but also of great importance to the Crusaders and Saracens; Akaba, at the head of the eastern gulf, being the scene of many fierce fights before Saladin finally obtained the mastery. As Dean Stanley has given an eloquent account of these changes, in his work on "Sinai and Palestine," the reader is referred to the latter for further information. The peninsula is administered by the Intelligence Department of the Egyptian War Office, the chief government official in the peninsula being the Commandant of Sinai, who resides at Kala'at-el-Nakhl, there being also a *Vazir** at Tor, though the latter town is practically controlled by the Quarantine Board having its centre at Alexandria. The relations between the Government and the tribesmen are negociated through the head sheikhs of the peninsula, each separate tribe having also its own sheikh, who seems to be invested with considerable authority.

The inhabitants of this mountainous region have fully maintained their good reputation for honesty, readiness to oblige, and independence of character. In general they are slight in build and somewhat short in stature, but very active climbers and keen sportsmen. Even the children early learn to recognize the plants and animals with which they come in contact, and the necessity of finding water and camel-food brings them into close acquaintance with every recess of their hills. Their *dwellings* are of the simplest description, consisting of dark or striped cloth stretched on a few poles, and so placed as to be under the protection of some rocky ridge. A partition in the centre divides them into quarters, the mens' from the womens', while furniture is limited to camel-saddles, baskets for obtaining camel-fodder, water-jars and a

* A military officer with civil powers.

few other simple utensils of primitive construction. Their *food* certainly does not err on the side of luxury, parched corn, coffee, lentil soup, and unleavened bread being the staple articles, while in the season dates and the fruits of the *nebk* (about the size of a crab-apple) are added to the store. The man's *dress* is equally simple, consisting of a galabia, or white cotton robe falling a little below the knee and drawn in at the waist by a leather girdle.

The head-dress consists of a strip of white cloth loosely wound in the form of a turban, with the ends falling so as to protect the head completely from the sun, but many of the younger men wear nothing but the skull-cap which underlies the turban. A dark burnous is often thrown over the galabia, but seems to be made of very thin material, except in the case of the well-to-do members of the community. The Arabs almost invariably go barefoot, though many of them possess sandals which are worn on state occasions; their weapons are flint-lock guns, often of great length and primitive construction, swords (usually straight) and daggers or knives worn in the belt or on the arm. The palm-groves and nebk-trees belong, not to individual owners, but to groups of three or four who form a close partnership, the scarcity of water or the ripening of the dates being the chief factors in determining their movements.

Though all the Arabs of the peninsula are included under the general term of the Towara (inhabitants of Tor), they are sub-divided into a number of tribes, three of which are of more importance than the others in the eastern portion of Sinai. Of these the most numerous are the *Emzeina*, who, according to the Ordnance Survey Report, are the descendants of an illustrious Arab tribe, and have the characteristics of being darker and wilder-looking than the remaining inhabitants of the country. The other members of our expedition were mainly recruited from the *Aleigat*, who live round Wadi Nasb, and the *Sawaliha*, who appear to be the most numerous of the three tribes above-mentioned.

Previous Geographical Exploration in Eastern Sinai.

Notwithstanding that so many travellers have visited the western side of the peninsula, it is a noticeable fact that scarcely any of them have examined the south-eastern region and still fewer have mapped any portion of the country under consideration. In 1844 J. Russeger published a map of Arabia Petrea and the southern part of Syria,

bringing together previous records so far as he had been able to obtain them, but he himself did not cross into Eastern Sinai. Nevertheless, the compilation is interesting as showing how little the detailed structure of the country had been examined, it being difficult to recognize any of the prominent valley-systems. Comparison with our map will show what fundamental differences exist between it and this compilation of the earlier efforts.

In 1868 the Rev. F. W. Holland, M.A., published a map in the "Journal of the Royal Geographical Society," in which he claimed the whole of the mountain region south and east of Gebel Katherina as original. Mr. Holland had qualified himself for the task by travelling through the greater part of Sinai, but his traverses were too rapid for great accuracy, and it is not surprising that in a country of this complexity, he should have missed many of the most interesting points. While the direction of the great artery of Nasb, its bends, and its relations to Wadi Kyd are well displayed, the existence of the coastal watershed was not recognized, and Wadi Letih, instead of being connected with Um Adowi, is represented as draining southward, whereas it will be seen that a twenty-foot gravel ridge deflects it northward.

Unless this ridge be actually crossed, it would not be difficult for anyone mapping from a distance to fall into this error, which is repeated in the Admiralty chart. A comparison with more detailed maps will show clearly where Mr. Holland has been misled, but full credit must be given to him for his pioneer effort to portray this difficult district.

About the same period Sir Charles Wilson and Captain Palmer, accompanied by a band of enthusiastic workers, commenced a detailed survey of the reputed sites of Sinai and the probable route followed by the children of Israel, their results being embodied in two large general sheets, extending from Wady Gharandel on the north to Wady Isla on the south. Whereas these maps mainly embrace Western Sinai (exclusive of the country south of Tor) the surveyors did not carry their triangulations far into the eastern area, though such points as they have determined have proved most useful to the present expedition, these having been verified, and used as the basis for our own survey.

Although a few minor points of detail are open to criticism, especially in connection with the extreme eastern border, this map is the most valuable contribution to the study of the peninsula hitherto published.

Finally, the Admiralty sheets of Nares and Moresby are, as might be expected, admirably correct for the coast-line, but the map, which deals

with the Gulf of Akaba, errs in much the same way as Holland's, and probably for identical reasons. In fact, it may be safely said that no valley direction can be assured in this district, without its having been fully tested and proved.

CHAPTER II.

SURVEY METHODS AND GENERAL GEOGRAPHY.

The present memoir embodies the results obtained by the Egyptian Geological Survey expedition when working in Eastern Sinai. The geographical deductions which follow are based upon the topographical map prepared with much care by my colleague, Mr. H. G. Skill, F.R.G.S., the surveyor of the party. The plan of work adopted was briefly as follows:—From Tor to the mountains the distance traversed was determined by a measuring wheel, whose relations to a chain-measured kilometre had been previously tested. On entering the mountains this instrument had to be abandoned, the Ordnance stations of Eth Thebt, Fersh Sheikh-el-Arab, Abu Mesud, and Beidha being adopted as points on base lines, from which a plane-table triangulation was built up. This was carried across the peninsula to Nebk, on the Gulf of Akaba, when a fresh base-line was measured on the plain near that locality and from it the southern portion of the peninsula was similarly triangulated. A third base was measured near the foot of Gebel Haimar in order to map the southern higher ranges as accurately as possible. A final check-base was laid down at Dahab, this differing from the same line on the map itself by an inappreciable amount.

A comparison of the sheets between themselves shows the *maximum* error to be about half a kilometre in any direction.

In order to further reduce possible errors, observations for *time* and *latitude* have been made at all the principal camps, *time* being determined by east and west stars, and *latitude* by Polaris and at important stations by circum-meridian stars.

In addition to the preparation of the map, Mr. Skill has carried out a large series of observations for the more accurate determination of *heights*. (1) with hypsometer, boiled at all camps and on all principal summits. (2) with metre aneroid, used for camps only, to avoid strain due to mountain climbing and (3) with an aneroid, marked in feet, used mainly for the ascents. The heights are determined from these according

to their respective values. In one case also a round of angles was taken to principal peaks.

Whenever camp was fixed for a whole day, barometer readings were taken at intervals during the day and as often as practicable camps were located on the same spot for two days, so that any such pressure changes might be observed and noted. All the subsequent remarks on variations of temperature, wind and weather, &c., are based on observations made by Mr. Skill, the temperature being determined by sling-thermometer (Elliott). Thus at each principal station the following notes were made by him, *time*, *pressure* and *height* by inch aneroid, hypsometer reading, temperature, direction of wind, if any, and whether cloudy or otherwise.*

As a result of these observations Eastern Sinai may be divided into several regions, meteorologically distinct.

1. The western plains characterized by high temperatures, and on the coast by north-west winds.

2. The Central Sinai plateau, marked during winter by low temperatures and sudden storms, and in summer by comparatively temperate conditions, stillness of the atmosphere and clearness of the sky.

3. Southern Sinai, south of the transverse divide much cut up by valleys which are at a lower elevation than those of the plateau, the temperature being consequently higher in winter. Apart from sudden gusts, this is also an area of still atmosphere, except for gentle breezes in the afternoon.

4. The Gulf of Akaba coast-line. This region is one of the most wind-swept on the face of the globe, the north-easter blowing without cessation for days together, the result also being that the temperature is lower than in the plains on the western side.

As regards more detailed weather conditions, snow covers the highest peaks in late December and January and in the case of Gebel Sabbagh lay at least for three days. Hail was recorded once in February. For rain the country is entirely dependent on the local storms, and speaking generally, it was most common towards evening time, especially in the spring. The quantity that falls during a storm must be very great, but the party was never in the centre of one of the very severe type.

The mountain ranges evidently affect the rainfall, thus the central chain catches the south-west moisture-laden winds which come up especially in November. It is impossible in view of the small amount of vegetation to judge at what height the maximum fall takes place.

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* For details see Appendix I.

Storms from November onward generally seemed to advance from the south-west, but in May the conditions appeared to be changed, a number of storms passing over Sinai from the north or north-west. The finest were noted in early November, in early March, and in May. With regard to wind effects, as different districts were passed over, it is difficult to give definite conclusions, but in general the stillness of the air is a marked feature in the mountain regions, especially at night or in the morning. In the afternoon, especially in spring, a light breeze prevails, but probably rarely exceeds a velocity of fifteen miles per hour. On the shores of the Gulf of Akaba, this rises to a velocity which may vary on an average from 35 to 50 miles an hour, i.e. moderate to fresh gale, and some movement of the air from the north-east is rarely absent.

From the 18th of January to the end of February westerly winds were frequent, mornings and evenings being clear and still, the western breeze rising in the afternoon. On some days, such as January 20th and 21st, sharp changes were noted during the day, a still morning being followed by north-east or south-east breezes about noon, while between 2 and 4 p.m. the wind had swung round to the west. Apart from the above period, north and north-east winds decidedly prevail for most of the spring months, though north-west winds held the upper hand in early June at Tor.

In conclusion, it is probable that the movements of the air currents are largely determined by the rift-structures of the country, many of the main valleys like Akaba, Raib, etc., having a distinct north to north-east trend. The wind entering them from the northern side is trapped as in a funnel, and follows the direction of the valley. In this connection it is significant that the records on the western side of the Red Sea indicate north-west winds as the most prevalent in spring.

The use of the compass in plane tabling had to be practically abandoned, the doleritic dykes which seam the country sometimes causing a variation from magnetic north of over ten degrees.

A brief remark may be made here as to the Arabs accompanying the expedition. The mountain staff consisted of two Ababda who had been with me in previous expeditions, Ibrahim Khalifa and Rean Abid, both of Qena, the first named being an especially expert climber. The Arabs of Sinai have maintained their reputation for honesty and readiness to obey, our sheikh, Ali Suliman, following his orders implicitly. We had the good fortune to be accompanied by one of the best guides in the country, Hudr Abu Merai, who is responsible for many of the names and much information; while in

the Letih district these were supplied by a younger guide, Hussein Abu Hassan.

With regard to the mountain climbing, our experience is the same as that of Sir Charles Wilson and the other members of the Ordnance Survey of Sinai, viz:—that no peak in Sinai is absolutely inaccessible. Our plan was to attack any mountain that was necessary as a station, however formidable it might appear, the attempt being in all cases crowned with success. One other point may be mentioned, viz:—the supposed dangers connected with an expedition in Eastern Sinai. There is no doubt that the Sinai Arab entertains a great dread of the dwellers on the eastern shores of the Gulf of Akaba, the inhabitants of Magna especially having a bad reputation. On only one occasion did we feel any necessity for sleeping under arms, this being due to several boats having put out from Magna to reconnoitre at Dahab, probably in consequence of their having seen our lights when we were taking some observations on a hill above the camp.

Interference by the Turks seemed also to be much feared, but though we worked far north of a line which the chief sheikh, Modakhel, had asked us not to cross, there was no suggestion at any time of danger from this quarter.

Illustrations.—Our special thanks are due to Herr Guyot, of Helwan, who kindly permitted us to use his photographic material for the purposes of this memoir, the views having been obtained by him during two scientific expeditions to Sinai. (See Plates II, IV, V, IX, XII, XIII, and XV to XVIII).

Dr. Grote, who has an intimate acquaintance with the peninsula, and has also formed a large photographic collection, has kindly permitted the reproduction of the plate which forms the frontispiece and Plate III. The remaining views were taken by the writer.

GENERAL GEOGRAPHY.

The traveller who enters Sinai by the quarantine port of Tor will, when standing on the shore and looking eastward, see a prominent mountain range running roughly north-west and south-east, and extending as far as eye can reach in both directions, only broken here and there by more prominent summits, among which the many-peaked Serbal in the extreme north, the dark plateau massif of Catherina or Zebir and the bold peak of Um Shomer opposite Tor, are especially

conspicuous. This great range is the western edge of the region which will be dealt with in this memoir and is itself a relic of a tectonic change of the first magnitude.

On crossing the hot and pebbly plain of El Qa'a (22·5 kilometres in breadth between Tor and Wadi Isla) in an easterly direction, the rugged range of mountains which apparently crosses the path appears impenetrable. No opening into the complex of hills is apparent, but wild valleys full of huge boulders descend steeply, until reaching the level ground they give rise to broad shallow watercourses meandering westward to the Gulf of Suez. One of these is the mouth of Wadi Isla, which for a distance of fourteen kilometres cuts through four important mountain barriers, forming a series of fine gorges, whose walls rise five hundred to a thousand metres above the valley. This groove forks at its eastern end, dividing into two valley systems, bent back parallel to the main watershed, the one, Wadi Tarfa, descending steeply southward between precipitous hills, while the other, Wadi Eth Thebt, broadens out at its southern extremity into a series of branches which end abruptly against the steep ridges of the Eth Thebt-Theman range.

Principal mountain chain and watershed and their relations.— Leaving these western valleys and ascending the peak of Fersh Sheikh el Arab at the head of Tarfa, or still better, the central mass of Abu Mesud, we obtain a general picture of both north-east and south-east Sinai, their boundaries, their principal summits, and their contrasts. The first fact that strikes the observer is that no second longitudinal chain of importance rises behind the one seen from Tor. Serbal is hidden by the dark plateau of Zebir (2600 metres), from whose summit rise a few isolated knolls, and which terminates in an abrupt wall to the south. Lower parallel ridges cross the country at the head of Wadi Rahabeh, terminating in the mountain mass of Um Shomer (2575 metres) this itself being the highest crest of the Rimhan range, which running south-east fills the angle between Wadi Rimhan and Wadi Isla. On the opposite side of the valley the thin ridge of Theman terminates in the conical peak (when seen from the north) of Gebel Eth Thebt (2403 metres), though the elevations of Theman and Eth Themnin are striking points rising precipitously from the same crest.

Main watershed. — Although the above ranges undoubtedly form the most striking mountain masses in the peninsula, including as they do its three highest summits, yet but few of them play any part in the formation of the central watershed. From latitude 28° 40′, a little north

of Sinai Convent, the latter runs on the eastern side of Wadi es Sheikh in a north-south direction, being formed by a comparatively low set of hills, the only summit of note on this line being Gebel Um Allowi or Derawi (2097 metres), Sinai proper (Gebel Musa) and Gebel El Deir being both left on the western side. The watershed crosses over the head of Wadi Sebaia at 1749 metres, but still maintains its northern trend. Here only is it formed by the main mountain system, the Zebir plateau in part draining to Wadi Nasb. At the head of the latter wadi, the plain of Rahabeh, it has a marked bend from Muharrig under the slopes of Um Koli running in a south-west direction, then turning south-east and finally east along the ridge of Abu Shejer and across the Tarfa Pass to Fersh Sheikh el Arab in such a way as to leave Um Shomer and the Rimhan crest also on the western side. From this point the watershed again resumes its north-south trend, joining the main mountain system at Gebel Eth Thebt.

From the above it is seen that the main mountain range from Sinai to Eth Thebt does not agree with the central watershed, but that the latter generally lies a short distance to the east of it.

Returning to our central summit of Abu Mesud, and looking southward, the central chain is seen to detach itself into several marked elevations more or less separate one from the other. For example Eth Thebt is part of a distinct mountain wall, immediately behind it rising the twin summits of Ethmid, themselves closely connected with the long thin crest of Halefia, and all being over 2000 metres in height. A marked notch separates these hills from a *sierra* (using the Ordnance term) or knife-edge range, which has its highest point, Gebel Sabbagh or Um Hash (2256 metres) near the northern edge of the crest, and whose two main summits when viewed from the north have a peculiar truncated step-pyramid appearance.

The character of the southern peaks cannot be determined from our selected summit, but south of Sabbagh the main mountain mass is no longer a single high range with lower ones on the east of it, but a double system of equal altitude, Gebel Ethnarbi or Jerjir being immediately west of Gebel Um Adowi, and both rising about 1869 metres above sea-level ; while still further to the south, the serrated Haimar-Hamar range, flanked to the west by the ridge of Sahara, maintains the duplicate character of the mountain scenery. West of Sherm the conditions are more complex, the hills sink below the three thousand-foot level, while preserving for a time their precipitous outlines, until finally they merge into the lower granite country and raised coral reefs which terminate in a 122-metre cliff at Ras Mohammed. Briefly, the map shows

the main mountain chain to consist in the north of long thin crests whose summits are from 2135 to 2438 metres in height with secondary chains very inferior to them, while south of the Um Adowi Pass the hill system becomes more complex and duplicated, the spurs rivalling the principal ranges, and the heights symmetrically diminishing from 1829 metres to 610 or less.

The watershed only follows the main chain a short distance south of Eth Thebt along the Ethmid, Halefia and Sabbagh ranges. In the centre of the latter it suddenly leaves the higher ridges and follows a lower slope, subsequently meandering among the western hills in such a way as to leave Um Adowi, Ethnarbi, and the great mountain mass connected with them on the east side of the line, and only meeting the principal axis in Gebel Sahara. From the Sahara-Aad line onward, it runs in such a manner as to have the long mountain slopes on the west, while the spurs, now higher than the watershed hills, are all again found on the eastern side.

Thus the main mountain line from Eth Thebt to Ras Mohammed seldom agrees with the central watershed, but the latter in the main lies to the west of it.

Character of principal summits on main chain. — The character of the principal hills of the main chain are as follows:— Gebel Zebir-Katharina. Though actually the highest mountain in Sinai (2602 metres Ordnance) this massif is easy of ascent, being less than 915 metres above Wadi Sebaia and showing the comparatively easy gradients of the schistose hills when not traversed by many dykes. At the summit it forms a broad plateau, studded with low conical hills, to which separate names are given, and three of which have been used as Ordnance stations. It stands in sharp contrast to Um Shomer (2572 metres) which instead of being dark-coloured like Zebir, is of the light granite tints and has a bold and striking outline, forming one of the most notable mountain features seen by travellers going down the Red Sea. It has been less frequently ascended than Zebir, as the ridge of Abu Shejer has first to be scaled and a steep descent made on the other side before the main peak is attacked. The Rev. F. W. Holland, who ascended it twice, states that there is no difficulty, except close to the summit, where it is necessary to remove boots. The twin peaks of Rimhan close by have also served as Ordnance stations, and are probably not difficult of access from Wadi Rimhan. Gebel Eth Thebt (2403 metres) is again a different type of mountain, felsite dykes forming steep precipitous sides being apparently in close contact one with the other. This, combined with the

rolling stones, renders the ascent difficult and tedious, and Mr. Holland who was the first to ascend it took four hours in reaching a height of less than 915 metres.

The two Ethmids and Halefia are probably as yet unconquered. They have to be approached by difficult mountain valleys, full of boulders, and with the higher summits of Eth Thebt and Sabbagh on both sides are of no special value as stations.

Gebel Sabbagh or Um Hash (2256 metres) has been first ascended by the present party. Though over 305 metres lower than Um Shomer and Zebir, it is nevertheless relatively almost the highest mountain in Sinai, being on all sides over 1220 metres above the camping grounds. The approaches are not specially difficult, though the boulder valley is of some length, while the numerous precipices can be rounded. The chief drawback to our ascent was the snow which lay thickly in places, some of the Arabs being severely frost-bitten in consequence.

Gebel Um Adowi though only 1830 metres high is nevertheless 1220 metres above the valley. This again has been ascended for the first time by our party. Here advantage has to be taken of the worn-down dolerite gullies and steep valleys, as otherwise the mountain, especially near the summit, is extremely precipitous. In fact most of the granite hills share this feature.

Gebel Ethnarbi, which is easier than the above, has also not previously been climbed. The ascent of Gebel Sahara has been made by Mr. Holland and by ourselves, while a cairn on Gebel Haimar shows it to have been previously scaled by some unknown traveller. This is one of the most difficult of the principal hills, unless attacked by a gully on the southern flank, whereas Gebel Aad, apparently not previously visited, was comparatively easy.

Aad El Gharbi, terminating the range, was also ascended by Messrs. Barron and Hardwick from the western side. Speaking generally, the mountains are characterized by the numerous precipices, by the narrow, often saw-like character of the ridges, and by the boulder-strewn nature of the valleys and gullies which descend from them.

Passes. — The above ranges which trend for a distance of over fifty miles in a north-east and south-west direction are traversible by baggage camels at three points only south of Wadi es Sheikh. The most northerly is the break between Gebel Rimhan and the Theman range formed by Wadi Isla, which leads directly to two passes. One of these, the Tarfa Pass, connects Wadi Tarfa (running parallel to the main watershed on the western side) with Wadi Rahabeh, and being the

main road from Tor to the great east-and-west artery of Nasb, is of vital importance to the country. The second one joins Wadi Eth Thebt with Wadi Humr, and is only available for lightly-laden camels. South of this point there is not even a footpath till the head of Wadi Letih is reached, though there are breaks at the head of Jerjir and Um Hash which are traversible by foot. At the head of Letih are two passes, the one into Budr used for sheep only, while that into Tehih is available for lightly-laden camels. There is a footpath from Letih to Wadi Rasheh and a riding camel (hagin) pass from Aad to Aad el Gharbi, but baggage camels coming from Tor to Sherm cannot cross the hills until Wadi Hashubi is reached. This is a very easy passage, but there is a second a trifle more difficult to the south which also enters Hashubi.

Returning to the centre of the peninsula, and standing on the summit of Sinai, the view to the east is not very striking. To the north-east the long white limestone wall of Gebel Gunna extends in an east-and-west direction, still further to the east breaking up into separate masses, and ending with the fine, truncated cone of Gebel el Ain. Further south spreads a flat or undulating granite plateau, out of which the Derawi-Er Rogha ridge, the dark peak of Habshi, and a few lesser heights, rise as isolated projections. To the south-east extends a mountain wall, which hides all the southern land from view. It is with this transverse divide that we have next to deal, constituting as it does the most important secondary mountain mass in the country, and forming a definite boundary between two different types of scenery.

The principal transverse watershed and the divide are identical at many important points. The latter unites with the central watershed at Fersh Sheikh el Arab (2152 metres) which together with Abu Mesud (2110 metres), forms the northern wall of a deep depression, the Fera el Adhal. Abu Mesud is one of the most prominent points in the peninsula, a dark cap rising from a plateau of some extent which is over 1830 metres in height, and is bounded on the southern and eastern sides by striking precipices of red granite. The watershed descends the north-east slope of Abu Mesud and then passes among lower hills leaving the fine white Gebel Beidha (1756 metres) and the many-peaked Ashara hills to the north of the line. Broken by two depressions subsequently to be described, the divide is continued in the Ferani chain, which is 1220 to 1677 metres in average height, and rises 915 metres above the surrounding valleys. In this half of Eastern Sinai both watershed and mountain chains show a curvature, being alternately convex to north

and south respectively. The result is the production of an amphitheatre bounded on the west by the Ferani range, on the south by the Gebel Um Malaga and its allies, and on the east by the shorter limb of Gebel Gnai and the associated coast range. To this I have referred as the Dahab amphitheatre.

The characteristics of the main transverse divide and watershed are :— (1) Gradual lowering of the range heights from west to east from 2135 to 915 metres, (2) Striking curvature of the watershed line, contrasting strongly with the comparative straightness of the main watershed.

Fersh Sheikh el Arab, Abu Mesud and Beidha have been previously ascended by the Ordnance Survey, and one of the lower Ferani hills had also a cairn on its summit, but all the others mentioned above or shown on the map as stations have probably been now visited for the first time.

Passes over transverse watershed. — There are only five possible ways over this divide, the first one between Fersh Sheikh el Arab and Abu Mesud being a riding-camel path leading into Fera el Adhal. Another is a steep pass leading from Um Rachal into Wadi Amlagh, in both the above cases the whole drop being on the south side. A third pass is an easy one for baggage camels from Wadi Shelala (on the western side of the Ferani range) to Rahab across a Nubian sandstone terrace only 92 metres high. The fourth is on the eastern side of the Ferani hills connecting Wadi Um Athaga and Lij, while the fifth, the Sharafa Pass, is the main route for baggage camels from Dahab to Sherm.

There is a remarkable feature common to all these passes, viz : *that the valleys they connect form five roughly straight lines, all parallel to one another and to the Gulf of Akaba, that is in a direction somewhat west of south.*

Within the area defined by the mountain walls of the central and transverse ranges are a vast number of hills, either running as long spurs projecting from the barrier range such as that of Gebel Mazea (Um Kheisen) and Genaui; as elevated plateaux, such as the Fersh El Gasab with the peaks of Genaui and Um Ekhlis rising from it; or as isolated peaks, such as Gebel Barakat.

Coastal watershed. — There is in addition a topographical feature of primary importance, a watershed line running close to the coast of the Gulf of Akaba, broken only in two places by the Kyd and Um

Adowi valleys. This line is formed by an almost continuous series of rugged ridges from 610 to 915 metres high, traversed by mountain passes in the main absolutely impassable for camels. Only at Wadi Gebila is there an easy passage to the gulf. South of this point the hills rapidly lessen in height, and the striking character of this coast watershed disappears, though in the twin hills of Themain and Ajuaf it again attains a height of 915 metres and deflects Wadi Letih into Um Adowi, finally ending in the summits of Gebel Haimar and Hamar (1382 metres) which project from the central mountain chain.

Between Ajuaf and Haimar it is formed by a gravel terrace only 6 metres high. Most of the hill ranges close to the coastal watershed are running at right angles to the latter. The country outside these three watersheds is composed either of comparatively low hills, in many cases isolated, or of coastal plain, which latter, however, is never of any great width.

Dyke country. — Although within the triangle formed by these three watersheds the district is largely composed of high ranges, yet in the south-eastern part, owing to the greater progress of denudation, a special type of structure has been produced, giving rise to what we may term "dyke-country." This consists of a series of ridges, due to felsite and dolerite dykes, running parallel to one another and separated by small valleys, the elevations varying from one hundred to about three hundred metres. Such a district occurs between Wadis Letih, Um Adowi and the Um Adowi mountain range, while another topographically more complex because two sets of dykes cross each other, fills up the interval between Wadis Kyd and Um Adowi. A third region of the same nature lies to the west of Dahab, bounded by the Nasb rift on the north, by the Ferani range on the west, and by those of Um Malaga and Gnai on the south.

Although the dykes are particularly striking in the above-mentioned dyke-regions, yet their influence in the determination of mountain form is to be traced throughout the peninsula, the summits of many prominent peaks being formed by felsite dykes, and like the latter having a marked north-east and south-west trend. This is especially the case in the hills immediately north of Wadi Nasb, and in the schistose district between Dahab and Nebk.

Geological composition has played an important part in the formation of some of the higher ranges. The summits of Zebir, Abu Mesud, the Ferani range, and Habshi, are composed of dark felsites which seem to have acted as hindrances to denudation, preserving the underlying

granite, and in the same way the schistose region with which the dark felsites are closely associated is on the average higher than the granite country which extends to the south and west of it.

As already stated the transverse divide separates two distinct types of country, the whole district on the south having been exposed to the intense action of denuding agents, while to the north of it the plateau structure is still to a large extent preserved, the granite having apparently only recently lost its capping of Nubian sandstone. Nevertheless the impression left on the traveller who keeps to the valleys north of the divide will be very different from the reality. Hour after hour he will find himself wandering between steep mountains, which rise from 467 to 610 metres on both sides of the gorges, and only after ascending these by steep gully and rocky slopes will he realize that the valleys are but deep clefts in a comparatively flat surface, though the dykes and minor ravines are already having a marked effect on the general character of the scenery. Owing to a low northern dip of 2° to 3° the overlying Nubian sandstone and Cretaceous limestone come successively to the surface, producing characteristic scenic features in each case. Wherever present the white grits of the Nubian sandstone give rise to remarkable isolated outliers, bounded on all sides by almost vertical walls, between which the valleys meander in labyrinths, curves and twists. At other points, the grits have disappeared and the basis of hard ferruginous sandstone on which they rest forms the broad sandy plains of Barga and Huthera, or flat plateaux such as Ejjibi, etc. To the south the sandstone forming at first a thin covering to the granite breaks up into isolated patches, which stand out prominently on the summits of Er Raimshi, Kharaza, and the neighbouring hills. The district mapped is bounded by the Cretaceous limestones which overlying the Nubian grits produce a long plateau facing the south with a very marked escarpment which is deeply cut into broad bays. These beds, as already related, do not reach the gulf, but terminate in the isolated tabular or truncated cone of El Ain, between which and the Gulf of Akaba is a complex of granite hills among which rise lighter isolated masses of sedimentary rocks. Far in the distance to the north a second limestone escarpment is visible, but this has not been visited.

Thus far, the country north of Nasb has been described in its simplest form, but a glance at the Ain el Hudera sheet (see Plate XXII) reveals the fact that the structure is far more complex than can be explained by mere geological succession, in fact on our northern boundary the map becomes a chequer work of intermixed scenic features, due to the limestones, sandstones, and granite respectively.

To the east of Wadi Ra'ib runs a bold wall of granite stretching to the northern watershed, behind which the country is hidden from sight. Standing on a central summit in the southern part of the sheet, * the observer finds himself face to face with a bewildering complex of topographical structure. In front lie the flat red-brown sandstone plateaux of Ejjibi, Abu Ghirsh, and Um Rowa, close underneath whose surface red granite walls are easily distinguishable. To the north-west granite ridges rise abruptly from between sandstone areas, or lie side by side with green-coloured limestone hills. To the west the green summit of Um Raiyig just appears above the Nubian knolls, while scattered here and there stand the vertical brownish pink outliers of sandstone, Gebel Barga, Amutamir, Jenach, and Ikri. Finally to the extreme north, the hills of Room el Seraier and El Hudera are isolated from the Gunna plateau to which they evidently belong.

As will be seen later the mystery of the hill distribution is easily explainable, for before us lies not merely a region where quiet deposition and elevation has alone played a part, but a land which has been the scene of dislocation and deformation, of rift and rent, and on which denudation has finally placed its seal and impress.

Summary.

Excluding the valleys, the surface features of the country are due to:

1. Geological structure, in which the following elements play part.
   (a) *Cretaceous limestone*, giving rise to the main escarpment with plateau summit, and numerous isolated green hills in the north.
   (b) *Nubian sandstone*, whose white grits produce a vertical-walled cliff under the Cretaceous plateau, or perpendicular-sided outliers weathering in a series of platforms. On the other hand, the lower ferruginous sandstones give rise to isolated flat plateaux or broad sandy plains, or form caps on the surface of the granite.
   (c) The *granite* north of Nasb is plateau-like, having only recently lost its cap of sandstone.
   (d) *Dark felsites* have, by their resisting power to denudation, given rise to several of the most important mountains in the peninsula.
   (e) *Dykes* of red felsite and dolerite have been instrumental in producing a number of ridges and mountain chains, many of them having the same trend as the majority of the dykes, viz: from north-east to south-west.

* See Plate XXII.

2. *Dislocation and fracture.*—These have been responsible for:—
   (f) *Production of main chain* by a fault with a proved throw to the west of over 5,000 metres, parallel with the border of the Qaa plain.
   (g) *Probable production of transverse watershed.* This latter being generally parallel to the transverse fracture between the Red Sea and the two gulfs of Akaba and Suez.
   (h) *Existence of coastal watershed,* which is in general parallel to the Gulf of Akaba.
   (i) *Complexity of geological structure in northern sheet,* * which is due to two main rifts running parallel to the Gulf of Akaba, and a number of minor fault systems.
3. *Denudation* has further been active in, or has caused:
   (j) The production of curious rounded knobs and pillars by the wearing away of the granite in shells, and generally the rounded outline of many granite mountains.
   (k) The existence of many of the serrated and knife-edge ridges characteristic of the country, denudation having been active on both sides till a crest is produced from which the water immediately flows off.
   (l) Remarkable hollows in the granite itself, whose mode of origin is still doubtful.

Valley Systems.

Even a superficial glance at the map is sufficient to show that the valleys present a regular arrangement which is quite unusual in most countries, the east-and-west drainage systems being crossed by long north-and-south depressions, whose straight-lined character is very noticeable, while at the same time a minor branching of a very complex nature adds to the difficulty of interpretation. The main valleys will here be considered separately in relation to their principal features only. They run very definitely in two directions almost at right angles to one another, viz:—west to east, and north to south, but at the same time present certain remarkable features demanding special attention.

East and West Valleys.

Wadi Nasb.—The longest and most remarkable of all the Eastern Sinai wadis is Wadi Nasb, which runs from the central watershed to

* See Plate XXII.

To the east of Wadi Ra'ib runs a bold wall of granite stretching to the northern watershed, behind which the country is hidden from sight. Standing on a central summit in the southern part of the sheet, * the observer finds himself face to face with a bewildering complex of topographical structure. In front lie the flat red-brown sandstone plateaux of Ejjibi, Abu Ghirsh, and Um Rowa, close underneath whose surface red granite walls are easily distinguishable. To the north-west granite ridges rise abruptly from between sandstone areas, or lie side by side with green-coloured limestone hills. To the west the green summit of Um Raiyig just appears above the Nubian knolls, while scattered here and there stand the vertical brownish pink outliers of sandstone, Gebel Barga, Amutamir, Jenach, and Ikri. Finally to the extreme north, the hills of Room el Seraier and El Hudera are isolated from the Gunna plateau to which they evidently belong.

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   (a) *Cretaceous limestone*, giving rise to the main escarpment with plateau summit, and numerous isolated green hills in the north.
   (b) *Nubian sandstone*, whose white grits produce a vertical-walled cliff under the Cretaceous plateau, or perpendicular-sided outliers weathering in a series of platforms. On the other hand, the lower ferruginous sandstones give rise to isolated flat plateaux or broad sandy plains, or form caps on the surface of the granite.
   (c) The *granite* north of Nasb is plateau-like, having only recently lost its cap of sandstone.
   (d) *Dark felsites* have, by their resisting power to denudation, given rise to several of the most important mountains in the peninsula.
   (e) *Dykes* of red felsite and dolerite have been instrumental in producing a number of ridges and mountain chains, many of them having the same trend as the majority of the dykes, viz: from north-east to south-west.

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* See Plate XXII.

2. *Dislocation and fracture.*—These have been responsible for:—
   (f) *Production of main chain* by a fault with a proved throw to the west of over 5,000 metres, parallel with the border of the Qaa plain.
   (g) *Probable production of transverse watershed.* This latter being generally parallel to the transverse fracture between the Red Sea and the two gulfs of Akaba and Suez.
   (h) *Existence of coastal watershed*, which is in general parallel to the Gulf of Akaba.
   (i) *Complexity of geological structure in northern sheet*, * which is due to two main rifts running parallel to the Gulf of Akaba, and a number of minor fault systems.
3. *Denudation* has further been active in, or has caused:
   (j) The production of curious rounded knobs and pillars by the wearing away of the granite in shells, and generally the rounded outline of many granite mountains.
   (k) The existence of many of the serrated and knife-edge ridges characteristic of the country, denudation having been active on both sides till a crest is produced from which the water immediately flows off.
   (l) Remarkable hollows in the granite itself, whose mode of origin is still doubtful.

Valley Systems.

Even a superficial glance at the map is sufficient to show that the valleys present a regular arrangement which is quite unusual in most countries, the east-and-west drainage systems being crossed by long north-and-south depressions, whose straight-lined character is very noticeable, while at the same time a minor branching of a very complex nature adds to the difficulty of interpretation. The main valleys will here be considered separately in relation to their principal features only. They run very definitely in two directions almost at right angles to one another, viz:—west to east, and north to south, but at the same time present certain remarkable features demanding special attention.

East and West Valleys.

Wadi Nasb.—The longest and most remarkable of all the Eastern Sinai wadis is Wadi Nasb, which runs from the central watershed to

* See Plate XXII.

the Gulf of Akaba at Dahab, a distance of 80 kilometres. For the first forty kilometres it trends nearly due east and west, cutting through two fine gorges on the way, but then is suddenly barred by hills rising from 366 to 915 metres above valley-level. As a result the valley turns abruptly northward for 16 kilometres, at the end once more resuming its eastward trend, and again forming a fine ravine which is more or less marked for the next thirteen kilometres, when the wadi turns southward almost parallel to its northward trending arm. Wadi Nasb receives the main part of the drainage of north-east Sinai, with the exception of a small strip drained by Wadi El Ain (and its tributaries) which opens out at Noweiba. The peculiar rectangular deviation above-mentioned is closely connected with two "rifts" whose geological and topographical importance will still further have to be emphasized.

Wadi Kyd.—Whereas the whole of the country drained by Wadi Nasb, about 2800 square kilometres, is only situated to the north of that valley, the feeders on the south being insignificant, Wadi Kyd, the most important valley in south-east Sinai, receives notable branches from both north and south. The actual Wadi Kyd rises in the basin-shaped amphitheatre of Fera El Adhal, (which is surrounded on all sides by mountains 1525 to 2135 metres high) and leaves it through a deep narrow cleft, which only opens out near to the point where Wadi Um Gerat joins it from the south. The latter valley is itself a combination of several draining the high mountain region of Eth Thebt and Humr, the most prominent being Wadis Humr, Ethmid, and Jendeli. The east and west direction of Wadi Kyd is continued until it is joined by the north and south-trending Wadi Melhadge, at this point still retaining the name of Kyd it is deflected due south for some miles, again turning east before entering the Gulf of Akaba. To the north of Wadi Kyd there is also a very complex group of valleys draining the northern wall, and opening into a single artery, Wadi Madsus, which itself enters Wadi Melhadge not far north of its junction with Kyd. Close to its final eastward bend Wadi Kyd receives another series of valleys draining the ranges of Halefia and Sabbagh, as well as the high plateau of Genaui, the principal branch being Wadi Yahamed. It may thus be truly said that Wadi Kyd drains nearly half the south-eastern portion of the peninsula. Rev. F. W. Holland, M.A., whose sketchmap of this district published in the "Journal of the Royal Geographical Society," 1868, is the only authoritative record of its topographical character, has also made the next big valley to the south drain into Wadi Kyd, but this conclusion is erroneous, and is due presumably to the rapidity of his traverse.

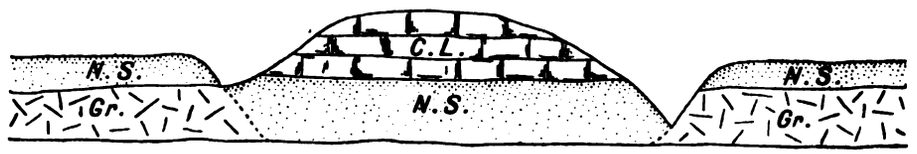
Wadi Um Adowi.—Wadi Um Adowi, which takes its rise in the hills behind Gebels Sabbagh and Um Adowi, stands in contrast to the two valleys above mentioned, because nearly all its principal feeders come from its southern side. The valley itself runs almost due east and west without any prominent bend. Its principal tributary is Wadi Letih, which taking its rise near the foot of Gebel Budr, for the first part of its course runs between the wild and rugged mountains of Sahara, Hamar and Um Zeynig, all over 1,220 metres high, on the north being the mountain masses of Ethnarbi, Um Adowi and Mandar. For the first part of its course it runs east and west, being then deflected northward by a low gravel ridge.

Wadi Aad.—The southern part of the peninsula is drained by valleys which receive but few tributaries, the principal of these being Wadi Aad, chiefly notable on account of its important water supply; Wadi Madsus, which towards the upper end turns completely at right angles to its initial course, a feature shared by several of these southern valleys; and Wadi Hashubi, which forms an easy road for baggage camels from the western plain to Ras Mohammed and the plains of Sherm. The reasons which have led to the distribution of these east and west valleys can only be inferred by analogy, but the origin of the north and south valleys with which we have next to deal is by no means so obscure, and can be directly traced to dynamical changes whose character, extent, and possible age may be more or less accurately determined. They belong in fact to the category of rift* valleys, of which the Gulf of Akaba is itself a striking example. It must be remembered that these are not single depressions, but rather a series of basins separated by areas which though higher than the main valley are of no great altitude compared with the bordering hills. Thus in the Great Rift valley the Dead Sea, Lake of Tiberias, Gulf of Akaba, and at the southern end Lakes Rudolph, Tanganyika, and Nyassa are all examples of such basins.

Um Raiyig-Shelala rift.—There are two main valley-systems of this kind in Eastern Sinai, and both extend far north of the south-eastern district. The first or Um Raiyig-Shelala rift, commences on the very edge of the escarpment of Gebel Gunna, in the extreme north of the Sinai region, but becomes prominently marked at a point where the

* These valleys would be better described as trough-fault valleys; where the word rift is used in this memoir it must be understood in this sense.

limestone hill of Gebel Um Raiyig is wedged in between two granite ridges.

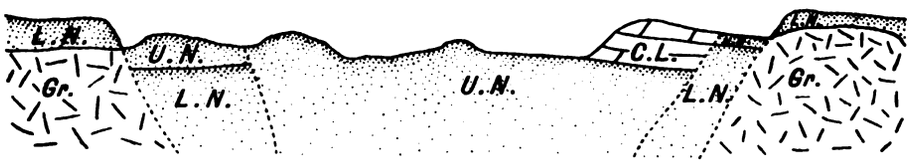


(Fig. 1).

To the south of this hill there is practically a continuous north and south valley, broken only by low and insignificant passes, and running far into the centre of the south-eastern district. Consequently there is an easy road down Wadi Um Raiyig to the north-trending portion of the loop of Nasb and Um Shelala, which again is separated by a low pass 91 metres high, (due to sandstone let down between the igneous rocks which rise 610 metres above it), from Wadi Er Rahab and the cross-cuts of Khlalat and Ekhmoin, the whole running almost at right angles to the main drainage valleys of the district. On the southern side of Wadi Kyd, Um Zegir continues this line, the rift only finally disappearing as such in Wadi El Tema. The main characteristics of the Shelala-Um Raiyig rift are:—

1. Its length, being about seventy-two kilometres long.
2. Its almost perfectly straight character, there being only a slight bend where Wadi Nasb turns east at the mouth of Um Raiyig.
3. The steep slopes of the bounding hills throughout the greater part of its course.
4. The occasional diversity of geological structure on both sides, especially marked where it separates the granite range of Ashara from the felsitic hills of Ferani.
5. The letting down of younger beds along the line, so that strata have been displaced from 200 to 600 metres at least, the result being that both Cretaceous limestone and Nubian sandstone exposures occur far south of their main outcrop.
6. The presence of older granites surrounded by the younger sedimentary rocks.

Raib-Melhadge rift.—This second rift has again a striking effect on the features of the country, and is longer than the previous one; but does not have marked rift characters throughout its whole length, though sufficient for Russegger's map to show it as an unbroken valley extending from north of Dahab to near Nebk. The first point that strikes the traveller going from Ain El Hudera to Dahab through Wadi Raib—erroneously named Wadi Zal by Holland—is the fact that the granite range extends far further to the north on its eastern than on its western border, a feature well brought out in Russegger's map. The eastern and western sides of the upper part of this valley are also in sharp contrast, the former being a continuous steep wall, while on the west the country is geologically far more complex, and has clearly undergone considerable disturbance. Cenomanian limestone ridges and plateaux of Nubian sandstone, the latter capping masses of granite, succeed each other in a way that shows the whole to be the result of folding and step-faulting.



(Fig. 2).

Thus in one place, a side valley, Wadi UmRowah, the features present are seen to be due to the breaking down of an anticlinal fold, the centre having been step-faulted. On both sides of the valley are low granite slopes—G.N. (see Fig. 2)—capped by the dark-red sandstones here named Lower Nubian—L. N.—at the foot of the cliff being lower plateaux of the same rock. The centre of the valley is occupied by rocks of much younger age, ridges of Cenomanian limestone—C. L.—and the white grits of the Upper Nubian—U. N.—being present below the level of the granite in the bounding walls. To produce this result there must have been a deplacement of at least 200 metres. In the valley itself the result is still more striking, for there Cretaceous limestones form a low ridge dipping steeply eastward towards the granite which rises immediately above it to a height of over 300 metres. Descending

Wadi Raib the conditions become simpler, and the nature of its origin becomes more and more evident, the Nubian sandstone on the west giving way to granite cliffs, and the valley becoming a broad highway bounded on both sides by precipitous heights. Yet scattered all along its course are low hills of white Nubian sandstone, and in one place Cenomanian limestone, the surprising result being realised that Cretaceous fossils are collected from a limestone on both sides of which tower granite cliffs to a height of over 500 metres, the extent of dislocation being here at least 700 metres.

There is thus no question that Wadi Raib and its extension in the eastern loop of Wadi Nasb is undoubtedly due to a trought-fault, while its parallelism to the Um Raiyig line and the Gulf of Akaba shows them to have all been formed as part of the same movement. At the mouth of Wadi Abuksheib, where the last Nubian outlier—a fine mass 100 metres high—is met with, and beyond that point, the fissure character disappears in the low granite country, though the valleys forming the main road to Sherm run parallel to the Gulf of Akaba, and are the only ones available for camels. At the head of the Wadi Gnai, which trends north and south, the transverse divide is crossed by a low pass, from the south of which extends the long and narrow furrow of Melhadge cutting in a straight line through a dark range of metamorphic hills, which rise on both sides to heights of from 300 to 500 metres. The north and south-trending depression can be traced as far as and including a portion of Wadi Letih, broken only by the insignificant transverse divide of Wadi Merari.

Three other valley-systems parallel to and agreeing in all main characteristics with the two above mentioned cannot be excluded from the rift category.

Hammam-Lij rift.—The first of these, about midway between Wadis Nasb and Raib, from two of the dominant valleys may be termed the Hammam-Lij rift. To the north it disappears in the faulted plain of Barga, but becomes at once evident in the granite range, forming the deep grooves of Hammam and El Araish. Crossing Nasb, it is continued up the western branch of Wadi Gurna across the Gurna pass, and then taking the same slight bend westward as the Gulf of Akaba at Dahab, or the Um Isma-Melhadge system with regard to Wadi Raib, it turns west of north; broken only by a low pass between wadis Um Shoka and Abuksheib it is continued up Um Athaga to Wadi Lij, and thence with slight bends to Saiamin and Madsus. In the latter valley the straight-line character altogether disappears, and assuming a south-east

FAULTING IN IGNEOUS ROCK REGION.
WADI SABAIYA

FAULTING IN SEDIMENTARY ROCK REGION.
WADI BUDR

direction, it runs into Melhadge a little north of the junction of the latter with Wadi Kyd. The view that this line is a rift is strongly supported by the fact that a small patch of Nubian sandstone is let in between the felsites on the pass crossing from Um Shoka to Abuksheib.

Two other marked valley-lines run parallel to the Nasb-Rahab groove, and though direct evidence is wanting, there can be little hesitation in regarding them as of the same origin. One of these is the Um Ghirat—Um Rachal system, whose full extent northward has yet to be traced, the second, the Hagar-Arras valley, which may be continued through Nasb to Jow, though this last is the most hypothetical of any. They both agree in having their southern termination at Wadi Kyd, and a marked sudden drop to the south at the transverse divide.

Origin and Correlation of East Sinai Rifts with those of Neighbouring Districts.

As the eastern rifts are but parts of a complex system, it is necessary to consider their relation to those on the western side and in regions immediately adjoining, before their age and origin can be adequately discussed.

El Sheikh-Tarfa rift. — Glancing at the map of the Ordnance Survey an important line is observable running close to 34° east long. in a north-south direction, which extends over 20′ of latitude, and is throughout traversible by baggage camels. The explored portion of this depression opens in the north with the remarkable break of El Watiya, a cleft across a solid wall trending slightly east of north. From here Wadi El Sheikh runs southward in an almost perfectly straight line, and from its continuation in Wadi Sebaia an easy pass leads into Wady Rahabeh, and another forms a connection with Wadi Tarfa. At the junction of the latter with Wadi Isla the straight character disappears, but Wadis Eththemnin and Theman joined by a narrow col, are not far removed from the dominant direction, and may possibly be referable to the same movement. On the west of the El Sheikh-Tarfa rift the Ordnance map shows plainly that there is a similar succession of connected valleys, but their trend is entirely different from those on the eastern side, i. e., the Akaba or north-north-east has been replaced by the Suez or north-west-south-east type. Such a line is roughly outlined from Wadi Entish through Wadi Sheiger and Hargus, but a particularly striking example is the one which commences with Wadi Suwig in 29°.2 north latitude and runs almost unbroken through

Khamila, the head of Taiyiba, Bark, Lebwa, Berra, across El Sheikh, and through Wadi Sahab, while beyond this point low hills carry on the road to Wadi Solaf. Here the line meets the remarkable granite ridge which bounds the Sinai mountain region on the north. It is of the highest interest to find that the Nagb Hawa pass, the only other entry into the Sinai region besides El Watiya, is precisely on its prolongation, while the rift is further continued in the plain of the Law (El Rahab), the Convent valley, and across the easy pass between the precipitous slopes of El Deir, Sinai, and the hill of Moneija, till it finally terminates at the point where it meets the El Sheikh rift previously described. Sufficient has been said to show the important contrast in direction displayed by the rifts on the two sides of the 34° long. line, and as Mr. Barron has made a careful study of the whole western district it will not be further necessary to consider the other valley-systems and the borders of the Gulf of Suez in connection with rift action.

How completely the existence of these dislocations is unknown is best shown by a study of a summary of our present knowledge brought together by Dr. M. Blanckenhorn, under the title, "*Die Strukturlinien Syriens und des Roten Meeres*," in the Festschrift in honour of Baron von Richthofen, Berlin, 1893.

In considering the origin of these structures, the field of discussion is a wide one. J. Walther in "*Die Korallenriffe der Sinai-halbinsel*," (p. 439-440, Vol. XIV. Abhand. Math-phys. Classe, Konigl. Sächs. Gesell. der Wissenschaften) has, basing himself on the Admiralty charts of Nares and Moresby, called special attention to the three-fold character of the Red Sea, Gulf of Suez, and Gulf of Akaba respectively. Each of these are now universally admitted to be rifts, but rifts of different age and different character. The Suez type, as we have seen, is of wide importance, it determines many of the Western Sinai valley-systems and the outline of the main mountain chain. On the western side of the gulf it has been instrumental in producing the parallel outlines of the lower chains in front of the Red Sea hills, and at the same time has been the cause of the precipitous and straight boundary of the Red Sea hills themselves. Though still requiring mapping, it probably is the origin of the longitudinal drainage in the Red Sea hills west of Abu Harba, Dokhan, and the Gattar ranges, and may be found to extend far north parallel to the main chain. Nor is it difficult in a glance at Zittel's geological map of Egypt to recognise the general parallelism of Wadi Qena and even in part of the Nile valley itself to the dominant trend. On the east of the north-south El Sheikh line, as has been seen, the Akaba type is alone present, so far as our studies are concerned, but further north towards

PLAIN OF THE LAW (EL RAHAB).

Akaba the faults drawn by Hull are of El-Sheikh character. On the eastern side of the Gulf of Akaba the fine precipitous ranges of Midian visible from Sinai, with the broad plain which runs parallel to them, must in all probability have the same character and origin as those previously described, but are not at present easily available for scientific investigation.

There is a third type of dislocation which has not yet been discussed, but which nevertheless may play a not unimportant part in the structure of the peninsula. Attention has been called by Walther (loc. cit. p. 440) to the remarkably sudden increase in depth south of the straits of Jubal, joining the Gulf of Suez and the Red Sea, and a similar sharp difference is noted with regard to the Gulf of Akaba, though not so pronounced as in the previous case. Blanckenhorn (loc. cit.) in his map shows a distinct transverse fracture south of Tiran Island, and Hull has drawn similar east and west faults at right angles to his north and south displacements. Turning to Eastern Sinai, attention has already been called to the transverse divide which separates two distinct types of country, standing at different average levels, and which may be due to a similar dislocation. It is difficult also to understand several other features, unless they be directly ascribed to transverse movements. On such a hypothesis the Haimar spur is easily accounted for, the watershed between Um Adowi and Kyd explained, and in the case of the elevation of Gebel Safara near Sherm, a transverse fault of importance is practically proved to exist. Although not possessing the convincing character of the evidence for north and south rifts, the existence of transverse dislocations in the peninsula itself may be postulated as *a first approximation* to the truth.

Conclusion. *It has been shown from the above remarks that the main features of the Sinai Peninsula have been produced by dislocation rather than erosion, fracture in three directions, either directly proved or in the highest degree probable, having determined the general structure of the country.*

Regularity of the valleys. — For another topographical problem the same explanation may suffice, though at present the precise method of solution is absent. This is the regularity of the valleys.

Directions. — Of 25 principal valleys (excluding those traceable to north-south rifts), which cross the eastern side of the peninsula, 17 show a south-eastward trend and in Wadi Letih the same direction is twice repeated, alternating with two bends of north-east type. Six

others follow a north-east course, being situated north of the divide, and west of the Nasb-Shelala rift, against which they terminate abruptly. In fact, the following generalization will not be far from the truth, 1st, that in the space between the divide, the El Sheikh and the Nasb rifts the valley directions are normally either slightly east of north-west of south *or north-east;* 2nd, in all other parts of the eastern side of the peninsula the dominant valleys trend east of north-west of south *and south-east.* In sharp contrast to these are the dominant lines of the valleys on the western side which are either north-west—south-east or south-west. We are unaware of any such regular arrangement in the backbone of any other mountainous country.

General level. — A good idea of the character of Eastern Sinai may best be derived from a brief statement of the proceedings of the party and the heights ascended, as determined by the inch barometer and hypsometer. The survey was carried out for 212 days, out of which 27 were rest days, that is to say, either shifting camp over ground previously traversed, delayed by bad weather, for inking maps, or other inevitable causes. Twelve days were spent more or less in the low plains, 23 days in valley-work, most of these in the earlier part of the traverse, a short experience proving that without ascents little efficient progress was possible. During the traverse nearly 150 ascents of more or less importance were made, and an examination of their heights will give the best clue to the differences in comparative level of the country examined. Adopting this method the total amount ascended was, excluding double stations, 65,422 metres, or an average of 309 metres per day. If the 143 summits alone be considered, the average high station ascent is 457 metres. The heights above valley level are subdivided as follows:—

On or above	4000 feet.....	(1220 metres) =	2
»	3000 »	(915 metres) =	10
»	2000 »	(610 metres) =	25
»	1500 »	(457 metres) =	36
»	1000 »	(305 metres) =	39

Turning now to the consideration of these in turn, the two results above 1220 metres give the actual level, the height of Sabbagh being measured from the highest point in the boulder valley where it was

possible to pitch a camp, while the ascent of Um Adowi was similarly made direct from the valley. Eth Thebt would be still higher relatively to its southern side, but the summit is nearer to valley level on the northern side.

The only mountain on the western side that can at present be included in this category would be the fine peak of Gebel Serbal, whose summit is 1433 metres above the Ordnance camp point, though possibly if figures were available Madsus and Tarbush would also be included. In fact Messrs. Barron and Hardwick have ascended the latter, but until their levels are to hand, it will be impossible to discuss the level relations of the mountain ranges to the big plain at their foot. At present Serbal, Eth Thebt, and Sabbagh must dispute the championship as being relatively the highest mountain in Sinai when considered from the eastern side only.

The ten mountains over 915 metres (the unascended peaks of Humr, Ethmid and Halefia are all probably over 1220 metres) bring out into clearer relief the difference between the relative heights of the two sides of the divide, and at the same time show clearly that the gradient of the valleys is very much steeper than the slope of the ranges. The first point is illustrated by the fact that nearly all of these are south of the transverse range, and the second that only one of these summits, Gebel Ethnarbi, is on the main chain. Mazea and Geraui, Um Ekhlis and Haimar are all on projecting spurs, while the Ferani range, which claims three of the remaining crests is within but a few kilometres of the sea.

The remaining mountain, Gebel Hormadjan, is higher above Wadi Isla than the crests dominating it to the west, thus being a further example of the second statement made above.

Of the 25 peaks above 610 metres, Abu Mesud and Fersh Sheikh el Arab, although nearly 2135 metres high, barely reach that level above the northern valleys, contrasting with Mazea and Geraui on the opposite side of Fera el Adhal, which though 305 metres lower, are both 915 metres above their base. Indeed of the 38 summits ascended north of the transverse watershed only seven exceed this limit, four of them belonging to the Ferani range and three being directly above the Nasb gorge. The remainder are either on the main watershed (Tellat Gimal, Sahara, Aad, etc.), hills closely associated with the main range as spurs (Um Taibekh, Maharrama, Genaui), peaks forming part of the Ferani range (Um Aleg, Lij, Et Wejera in fact all the summits of this range are between 770 metres and 915 metres above valley level), and the highest peaks of the schist region (Madsus). The granite ranges immediately west of the

schist region, and especially the great plateau of which Abu Mesud is the highest summit, are also over 610 metres above their southern valleys.

Leaving aside our own results, the Ordnance survey bears further evidence to the significance of the transverse line.

Only Zebir is near the 915-metre line, such important peaks as Um Shomer, Derawi, Er Rogha, Sinai, El Deir and the granite masses connected with them being barely above the 610 metre level.

Above or on the 457 metre level are the remaining important peaks of the northern plateau (Beidha and Hezaima), several of the hills of the eastern schist district, the striking white summit of a long ridge running parallel to Um Adowi on the southern side (Barakat), two twin hills (Themain and Ajuaf) conspicuous objects near the sea-coast of Nebk, the principal summits of the cluster of granite hills west of Sherm, the minor summits at the head of Wadi Letih, the granitic members of the transverse wall between Ferani and the sea, several of the isolated hills rising out of the centre of the Dahab amphitheatre and the plateau above the deep gorges of Wadi Nasb and Wadi Raib.

The levels lower than 457 metres may be said to include the limestone and sandstone hills of northern Sinai, and the granitic summits adjoining them, the dyke regions already mentioned, and the foothills rising above the coastal plain.

Speaking generally, the country north of the transverse divide tends to the plateau type, but is bounded by a range 610 metres (not exceeding 915 metres) on the west, and is deeply cut into big rifts of regular direction. Apart from isolated peaks and narrow ranges (Habshi, Um Allowi) its surface has been but little affected by denudation.

The country south of the transverse divide is, on the contrary, cut up into a complex of spurs and ranges, separated by valleys running more or less regularly in two directions, the higher summits being usually 610 metres to 1220 metres above valley level, while many of the lower ones exceed 762 metres.

Summary.

Before proceeding to further considerations, a summary of the main results may be here brought together:

1. The main mountain range from Sinai to Eth Thebt does not in general agree with the central watershed, the latter being usually a short distance to the *east* of it.

2. The main mountain line from Eth Thebt to Ras Mohammed seldom agrees with the central watershed, but the latter in the main lies to the *west* of it.

3. The main Sinai Peninsula mountain system consists of a series of long crests, (separated by high passes) trending north-east—south-west, and gradually lowering from 2592 metres in the north to sea-level at Ras Mohammed. The principal chain is bordered by a secondary longitudinal system, lower than the former in the northern half of the area, but together with the east-west spurs thrown off from it, rivalling it in the southern half. From Wadi Hebran to Ras Mohammed only two easy passes cross the chain, two others also being available for baggage camels.

4. East of Fersh Sheikh el Arab, a transverse system runs west and east to the Gulf of Akaba, the general level of the country to the north of it being higher than that to the south. The range is broken up into hill masses, gradually diminishing from 2135 metres at Fersh Sheikh El Arab to 457 metres at the Gulf of Akaba.

5. The *transverse watershed* is *identical* with the *transverse chain* at most of the important points.

6. The *transverse chain* is crossed by *five* passes (*two* available for baggage camels), which have this remarkable feature in common, viz., *that the valleys they connect form five roughly straight grooves, all parallel to one another and to the Gulf of Akaba, that is, in a direction somewhat west of south.*

7. A *coastal watershed*, broken at two points, runs close 1st to the Gulf of Akaba, and 2nd to the coastal plain, until it joins the spur of Haimar, running out from the main chain.

8. The *transverse chain* separates two districts:— a *northern*, still retaining much of its original plateau character, and having an *average* level of over 1220 metres, except where it is cut through by deep, narrow gorges; and a southern, cut up into a multitude of ranges and peaks, the valleys only reaching 915 metres at the bases of the main chain.

9. In consequence of the above, the northern mountains, though absolutely higher, are relatively lower above the valleys (rarely exceeding 610 metres) than the southern ones, which commonly rise from 610 metres to 1220 metres above the valleys at their base.

10. All the main eastern mountain ranges are included between the above watersheds, outside being either foothills, coastal-plain, or merely fringing coral-reef.

11. Within the hill-districts, the superior hardness of igneous dykes has produced a special form of country—*Dyke-Country*—in which the

harder rocks have given rise to parallel ridges separated by shallow valleys.

12. *Valleys.* — The three principal east-and-west trending valleys stand in sharp contrast to each other, thus:—

Wadi Nasb receives almost all its drainage from the north; Wadi Kyd drains the country both to north and south; Wadi Um Adowi drains the country mainly to the south of its course.

13. There are *six* north-and-south valleys, or rifts, each consisting of deep depressions bounded by steep-sided hills, running in a straight line, and only separated from one another by low easy passes. *Five of these valleys are roughly parallel to each other and to the Gulf of Akaba*, and where they meet the transverse valleys, in many instances the latter are deflected.

14. Three dominant valley-directions are noticeable; *south* of the transverse chain these run *south-east;* north of that chain, *north-east;* while the third system is that above-mentioned.

15. In contrast with these, on the western side of the main range, the predominant direction is north-west—south-east in the north of the peninsula, and south-west on its south-western side.

CHAPTER III.

DETAILED TOPOGRAPHY OF EASTERN SINAI.

In the desert area now under consideration the question of water supply and fuel is always one of prime importance, and upon these in part depends the nature of the route selected by the traveller. The visitor will have a choice of four principal roads by which to enter Eastern Sinai.

1. *Suez-Sinai road.*—The first, from Suez to Gebel Musa, will naturally be taken (either coming or going) by all those interested in the study of the Exodus, but need not be further dealt with here, as its various branches have been exhaustively discussed by the Ordnance Survey, and further examined by the Egyptian survey party under Mr. Barron. From the tomb of the Sheikh Salah in Wadi Sheikh near the Sinai Convent, a low and very easy passage leads into the plain of Sennèd, from which valleys branch out toward the east giving ready access to Dahab and Noweiba, on the Gulf of Akaba. Another easy

pass connects Wadi Sheikh with the plain of Rahabeh, at the head of Wadi Nasb.

2. *Tor—Wadi Hebran.*—A second road leads from Tor, the port of Sinai to the Convent through Wadi Hebran. Tor, in latitude 28° 13′ north, longitude 33° 37′ east, is a small town situated at the head of a bay protected on the west by the long point of Ras Tor, itself due to the presence of a coral-reef, and on the south-west by the Erg Riyah reef, with a passage on either side. The town consists of not more than a dozen large houses on the sea-front, these being mainly buildings connected with the Government or Quarantine service, and a mosque. Steamers have to anchor some little distance from the shore, stores, passengers, etc., being landed by feluccas and boats at a low pier of no great length. The population is of a mixed nature, the leading Government officials being Egyptians or Syrians, while the Quarantine service includes Greeks, Germans, and English in its ranks. The local trade is practically in the hands of two Greek shop-keepers who carry on a limited business with the inhabitants of the mountain districts. The monks of the Greek church connected with the Sinai Convent also have a large church and monastery in the town. Finally, the lower-class portion of the population has gained an unenviable notoriety for dishonesty, a reputation which was well maintained during our stay at Tor.

To the north-north-east behind the town rises the hill of Gebel Hammam Seyyidna Musa with its landward slope dipping steeply eastward to the broad plain lying between it and the mountains. To the north and east extends the plain of Qa'a backed by the varied peaks which rising abruptly from the stony desert form a mighty unbroken wall for many miles. Here and there some summits stand out in more prominent relief, Serbal, Zebir, Um Shomer and the ranges near Eth Thebt being conspicuous objects in the landscape. Near the town to the north is a group of palm-trees, and a little further on is a marked depression, El Wadi, which appears to be closely connected with Tor Bay and is a direct prolongation of the arm of the sea. This is practically one of the principal centres of the Bedawi in the peninsula, mud houses, each situated in a palm grove, being numerous. Here also are wells of good water, where the traveller by the Hebran route obtains the supply necessary to take him across the desert to the mountain valleys.

Beyond El Wadi the plain, at first broken up into ridges and shallow valleys, the latter often bounded by low light-coloured marly or gravel

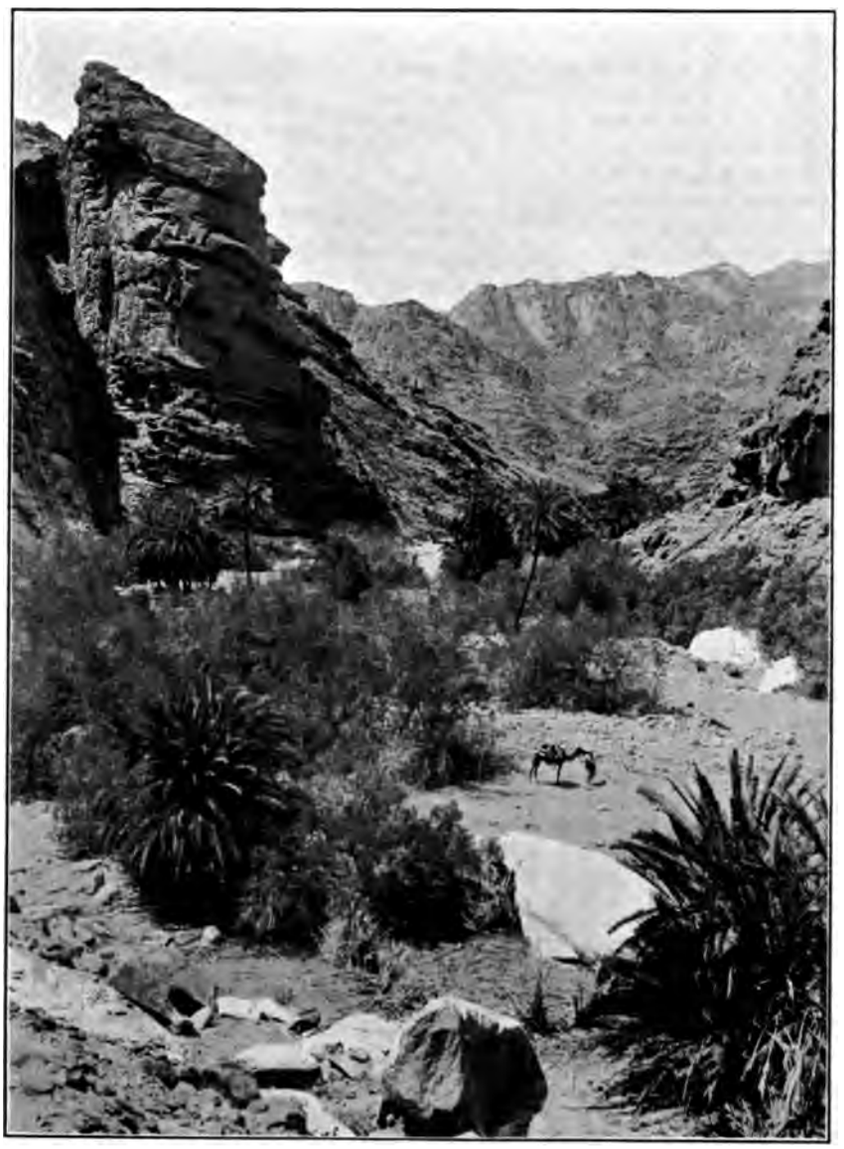
cliffs, extends to the foot of Serbal. Although in part washed away, the road made by Abbas Pasha from Tor to Sinai is in many places still in good preservation, and can be clearly traced on both sides of the plain. As the mountain slopes are approached, the broad expanse is more and more cut up by steep-sided gullies, until suddenly a narrow cleft between two walls of red granite leads us from the dusty desert to the relatively luxuriant mountain valley of Hebran, with its running stream, its beautiful palm-groves, and vistas of steep mountain peaks or abrupt granite slopes. This is undoubtedly one of the most beautiful mountain valleys in Sinai, and from the pass at its head the steel-grey sides of Serbal and the bold dome of Madsus, tinted at sunsetwith deep shades of violet and purple, form a picture not easily forgotten. So many travellers have followed this route that its features have been thoroughly described, and as it also falls within the purview of the western party, we need not longer dwell on the tamarisk-groves of Solaf (in May exuding the sweet and glutinous manna), or the curious rifts of Watiya and Nagb Hawa, piercing the otherwise unbroken mountain barrier. At Watiya gorge, or a little before, this route unites with most of those from Suez.

3. *Tor—Ras Mohammed.*—The third route is one which is followed by those visiting Ras Mohammed or Sherm, and has been surveyed by Messrs. Barron and Hardwick. This route practically follows the sea-coast, or the plain of El Qa'a can be crossed and the central chain be skirted, until the easy pass of Hashubi is reached.

4. *Tor— Wadi Isla.*—The fourth route is the one by which we entered the mountain district, but before describing it the remarks on the neighbourhood of Tor may be completed. To the south-east and south of the town are three groves of palm-trees, one marking the quarantine-station, another further south, formerly marking the village of Qrum.* In the desert to the east, there are also a number of enclosures surrounded by strong wire netting, these being used as a camping ground for the pilgrims from Mecca, who are obliged to stay here for twelve days, and if any case of epidemic disease breaks out in the enclosure, those camped there have to recommence a quarantine of the same duration; when the cholera attacked Egypt in 1893 there were no less than 16000 to 17000 people thus imprisoned at one time.

Qa'a plain.—On leaving Tor, water having been obtained at Qrum, the great plain of El Qa'a has to be crossed before the mountains

* Quarantine buildings have now been built on the site of the village.



TYPICAL VALLEY OASIS IN WADI HEBRAN.

themselves are reached, its breadth between the town and the mouth of Wadi Isla being 22.5 kilometres. This great expanse, stretching away to the north-west and south-east as far as eye can reach, is topographically very uniform. At first near the sea-shore it is of raised beach character, shells of various modern Red Sea types being scattered over the surface, but further to the east the ground becomes more pebbly, consisting of quartz, felspar, etc., derived from the igneous rocks of the mountain district. An interesting feature, too, is the presence of a number of low sand-dunes rising from the plain, and probably never exceeding a metre in height, their crests having a north-east strike, while their steepest side faces south-east, these characters being due to the prevalence of the north-west wind. As the mountains are approached large boulders of granite, quartz-felsite, etc., are more and more numerous, and the plain becomes a series of low ridges separated by shallow depressions, which are the continuation of the ravines descending from the high ranges to the east. This region is one of the hottest in Sinai, the shade temperature on October 20th, 1898, being 97°.7 F. at 5 p.m., on the 21st, 84°.9 F. at 8 a.m., and on the 22nd, 100°.6 F. at 2 p.m. It will be readily understood that, under the circumstances, vegetation does not flourish, as there is absolutely no shade throughout the district, and consequently the normal temperature is far higher than that represented by the above figures. Nevertheless the *boural* (*Zygophyllum album*), the well-known fleshy-leaved plant, is not uncommon, probably obtaining its water-supply from the moisture which sinks into the ground after the winter storms.

As the hills are approached, they are seen to possess one very striking feature, being striped in a remarkable manner by bands of red and dark-green colour, these being dykes of igneous rock, while the mountains themselves rise tier above tier, the magnificent rose-coloured precipices of Um Shomer being especially conspicuous. A few granitic ridges, owing their origin to the presence of the hard dykes, form the advance guard of the main hill-system, but with these exceptions, the boundary between the low land and high ground is very abrupt. Looked at from below the barrier seems impenetrable, and it is only when within a hundred metres of the opening that the ravine of Isla becomes visible, the valley having cut deeply into the gravels of the plain for some distance from the mouth of the gorge, before it becomes a shallow water-course like those previously referred to.

These raised plateaux of detrital material, terminating in abrupt cliffs at the edge of the valley are, like the dykes, amongst the most striking features of the peninsula, and are of great importance to the

traveller as camping-grounds in a district which, especially in winter time, is liable to sudden and destructive storms, the water, pent up between walls of solid rock, sweeping all before it in its wild rush. The anxiety of the sheikh of the party to avoid camping in the ravine itself was very noticeable, and the fear was justified when, a week later, a storm burst over the district, giving rise to one of the "seils" the name by which these torrents are known. The chief danger lies in their suddenness, and in the local character of the rainfall, so that a heavy rain may be falling in the higher valleys, while those camped below may be totally unaware of danger till the flood is on them. At the foot of the hills a little to the north of the valley opening are some ruined stone buildings of small size, while on the rocks at the entry of Wadi Isla are some drawings of ibex, etc.

Wadi Isla.—Wadi Isla throughout its whole length possesses characters suggestive rather of a rift than an erosion valley, being a steep cleft running without many flexures between hills which tower above it as bold precipices or steep slopes. Although it cannot be compared with the splendid gorges of the Alpine regions in Europe, Asia and America, owing to the comparative absence of vegetation and water, Wadi Isla possesses nevertheless a rugged beauty of its own, and the sharp contrast between the darker tinted gneisses which form the lower slopes, and the rose-red granite of the peaks of Um Shomer and Rimhan removes to some degree the sense of bareness and monotony which might otherwise be experienced. The occasional palm-groves scattered here and there possess a special charm from the fact that they are unexpected, and the small waterfall which is met with about halfway, trickling over ledges covered with moss and maiden-hair fern, and giving rise for a short distance to a stream which too soon loses itself in the dry pebbly soil, is fixed on the memory by its very rarity. From time to time the valley narrows, forming ravines bounded by steep walls of rock whose lower portions have been smoothed and polished by torrent-action. But rarely does it broaden out sufficiently to allow of the formation of gravel terraces, there being probably about three of these along its course. Tributary valleys are also very scarce, the principal one from the north being Wadi Emlaha, a wild boulder-strewn ravine coming through dark gneissose hills, behind which can be seen the red-coloured precipices of Gebel Rimhan. Further to the east Wadi Hormadjan enters from the south, rising in an amphitheatre surrounded by a semi-circle of mountains over 1000 metres high. The amphitheatre is connected with a lower valley by one of

the steep, rocky shoots (these smooth rocky slopes of 15 metres in height are in reality "dry waterfalls" during the greater part of the year), so characteristic of Sinai, and which form one of the most dangerous elements when climbing in the district, though fortunately the one here present can be easily rounded by following the talus slope. Gebel Hormadjan on the eastern side of the semi-circle overlooks Wadi Theman, which possesses one or two palm-groves, and is backed by the wild and jagged range of Safsaf, a southern prolongation from Eth Thebt.

Eth Themnin pass.—Wadi Theman is connected with Wadi Isla by a high pass, only traversible on foot, the upper part being somewhat broken. To the east of the pass the ridge rises in a rapid knife-edge, which terminates in Gebel Theman on the main Eth Thebt range, but an ascent of the latter from this side would be risky if not impossible. Time and increasing difficulty obliged the station to be placed lower than was advisable, although it was already over a thousand metres above the valley. It was, however, satisfactory to find that the guides were supplying the same names in most cases as those given on the Ordnance Survey map. Wadi Isla is formed by the confluence of two large valleys, Wadi Tarfa, descending from the north, and Wadi Eth Thebt, which, after a short northward course, bends sharply westward. The latter is bounded on the north and east by the ranges of the principal watershed, whose average height varies from 1525 to 1830 metres, while on the west the knife-edge of Theman-Eth Thebt rises in a series of steps to over 2435 metres. The valley at its upper end is formed of a number of broad feeders, descending steeply from the hills, but soon uniting in a wide expanse, where some Arabs are usually camped. One of these brought in a number of hyrax skulls, but the animal itself was not observed. Near its junction with Isla, Wadi Eth Thebt contains a very beautifully situated waterpool, hidden among boulders and a grove of palm trees, near by on a low rise being a few ancient monastic dwellings built in the rectangular form common to this type.

Humr-Eth Thebt pass.—One of the few passes connecting east and west Sinai runs from this valley into Wadi Humr. It is practicable for lightly-laden camels, but unsuitable, owing to the steepness of the rock-steps, for a caravan bearing heavy loads or having to deal with delicate instruments.

Two ascents of the central watershed were made in this district, both being of no serious difficulty, and under 1830 metres high. Tellat Gimal owes its long ridge to the presence of a felsite dyke, similar rock features also determining the structure of many of the neighbouring summits, while they can also be traced seaming the hills as bright-coloured bands for many kilometres.

Up to this point animal life had been but little in evidence although tracks of leopards and gazelle were numerous and two of the former animals had been seen by two of our Arabs when descending Hormadjan. Ibex, too, are evidently abundant in the central watershed, one, a female, coming close to the plane-table on Tellat Gimal, while subsequently Skill saw a fine male and several females on the slopes of Fersh Sheikh el Arab.

Wadi Tarfa.—This valley, which descends rapidly from the Tarfa pass, (Thilmet el Tarfa) is enclosed on both sides by hills which do not, however, compare in relative height with those bounding Isla and Eth Thebt, although the absolute height is not much less. Its ascent is not particularly easy for camels, there being a number of awkward rock-steps, having a smooth and slippery surface, but from the scenic point of view, the tamarisk bushes (tarfa) which give it its name lend a certain beauty to its lower portion ; while the upper part, at the foot of Fersh Sheikh El Arab, is very bare, being simply a stone-covered waste enclosed by a semi-circle of hills and seamed by deep nullahs draining the higher ranges.

Captain Palmer thus describes Wadi Tarfa : "From the pass begins the descent of a steep formidable *nayb*, by a winding and extremely rocky trail. A mile down, you come to a straggling line of *Tarfa*, and at intervals to pools and trickling water ; these continue for the next five miles, the glen throughout this distance being narrow and winding, the scenery sublime, the path up-and-down and stony, with several rocky steps and platforms ; there are also at some points passages between fallen rocks so narrow that camels with bulky loads have difficulty in scraping through."

Near its junction with Wadi Isla Wadi Tarfa receives the large tributary of Wadi Rimhan, descending abruptly from the north-west, a boulder-strewn groove such as is characteristic of this region. The Tarfa pass (over 1830 metres) is simply the lowest part of the bare range of hills which here forms the boundary between the Nasb and Isla drainage systems and rises to 2152 metres in the high summit of Fersh Sheikh El Arab, situated at the point where the central

JUNGLE SCENE IN WADI ISLA.

watershed bends sharply at right angles from an east-west to a north-south direction. The ascent of this mountain presents no great feature of interest, though the absolute barrenness is to a certain extent relieved by the presence of many bushes of *myrrh** (*Pyrethrum*), which is immediately noticeable owing to its strong aromatic smell, and *hamr* (*Anabasis setigera*), which was eagerly sought after by the Arabs for their camels. Numerous ibex were also seen on the sides.

Wadi Nasb.—On crossing the pass, an easy path leads into the broad plain of Rahabeh, which here forms the head of the Wadi Nasb, the most important valley of Eastern Sinai. The latter takes its rise in a high region lying between Um Shomer and Gebel Um Ja'assa, the southern summit of the Katherina plateau (Gebel Koli of Ordnance Survey), consisting of a number of low ridges owing their origin to the hard dykes which as red bands form their crests. From thence it descends in three or four principal arms, which themselves are broad and open, at the same time containing much vegetation, *kharit* (*Caroxylon fœtidum*) forming large bushes and occurring in abundance. Wadi Nasb at first runs between the foothills of the Fersh Sheikh El Arab and Abu Mesud ranges on the south, and those of Nakhala and Khasib on the north. The only important tributary from the north is the Wadi Rutig, which is the main road leading to the Sinai Convent from Rahabeh, but presents no special features of interest. Wadi Khasib is only a small valley, but contains pools from whence the expedition obtained their water when camped in the neighbourhood.

From the south enters the broad straight Wadi Wa'era which on the west is bounded by the spurs of Fersh Sheikh El Arab, and on the east by the lower range of Gebel El Feringhi or Gebel Hadid. At its head are a number of stone-circles, some of them double, e.g., almost 8-shaped, and also several rectangular single-chambered monastic buildings were noted. From this point an easy path leads across an undulating region of low granite hillocks to the plain in which Wadi Um Jiraf takes its rise, the latter thus separating the isolated hill-mass of Gebel Hadid from the high range of Abu Mesud, which rises rapidly above the level to over 600 metres. This locality has attracted a good deal of attention owing to the fact that the quartz-veins traversing the low country carry a considerable amount of good iron ore in the form of hæmatite and iron ochre, while a block of good magnetic iron ore was also obtained

* The Arabic names are here given for the convenience of those to whom the plants would be thus described by the Arabs.

on the road, but unfortunately not *in situ*. In Wadi Um Jiraf, Nabathean inscriptions have been found on some of the stone-circles which are crowded together in its upper portion, a clear proof that these curious structures either antedate or are contemporaneous with the Edomite occupation.* Abu Mesud presents no difficulty if ascended from its western side, and well repays the climb, it being over 2000 metres high, and commanding a view of the country in all directions. To the north-west and west the view is closed by the broad plateau of Katherina, and the rugged red peaks of Um Shomer; to the southward are the mountain wall of Eth Thebt, the twin summits of Ethmid, the long, thin crests of Halefia, and the truncated pyramid of Gebel Sabbagh; while to the east, the eye rests on a dark, confused mass of hills, mainly composed of schists contrasting strongly with the granite which surrounds them on every side, one of the most arid regions in the whole peninsula—barren ridges dominating sinuous gorges where only a scanty herbage finds a foot hold. Behind these is the broad deep blue line of the Gulf of Akaba, beyond which rise the purple hills of Midian. The mountain itself is the highest summit of a broad plateau over 1525 metres high, which terminates in abrupt precipices to the east and south, but slopes more gently towards Um Jiraf and Nasb. It is in fact, the most prominent member of the transverse divide already referred to, with the Fersh Sheikh El Arab and the high ground at the head of Wa'era forming the northern boundary to the remarkable basin of the Fera El Adhal which, enclosed in a semi-circle of mountainous barriers, only has one outlet, viz., to the east by the deep ravine of Wadi Kyd. The pass of Wa'era is therefore not only a break between two mountain masses, but the boundary between a high northern plateau and a deep depression, a steep path only traversible by lightly-laden camels leading down the rock-face. From the northern side of Abu Mesud a number of small valleys descend to join Wadi Nasb, the most interesting of these being Wadi Wadhih, which has a large group of stone-circles at its head.

While Abu Mesud (2110 metres), covered with dry vegetation to its very summit, is the culminating point of the plateau, other elevations rise from the same base, appearing as peaks of marked prominence when viewed from the valleys at their foot. The most notable of these are on the eastern side, Tha'albi, Abuzag, and the fine pink granite hill of Nakhara forming the edge of the mountain mass in that direction. It may be added in passing that the darker colour of Abu

* See also C. Wilson, "Ordnance Survey of Sinai," pp, 194-197 for fuller details.

Mesud and the flat character of the whole range is due to the presence of a felsite capping which has been partially removed by denudation. The presence of this rock has also played the most important part in determining the very flat summit of the broad Um Katherina, which rising over 2440 metres above the sea, is at once the highest and most conspicuous of all the Sinai hills, though lacking the rugged grandeur of its much-broken and deeply-carved granitic rival, the great peak of Um Shomer.

On the northern side of Wadi Nasb, the orographic character of the country undergoes a marked change, there being no longer broad, lofty table-lands, but hills lying in long lines trending normally in a direction parallel to the valley itself. Some distance to the north extends the ragged *sierra* which has Derawi (Um Allowi) and Er Rogha as its principal summits, while the lower hills extending between it and Nasb, at first sight from below so confused and barren, are seen on closer inspection from the higher summits to possess an extraordinary parallelism or to constitute a netted belt of ridges, the cause of these appearances being easily traceable to the presence of two systems of hard dykes crossing one another. There are, in addition, two hills in this direction which still show the flat-topped character, viz., Nakhala and the distant Habshi, both owing their form to the geological cause above-mentioned. Returning to the junctions of Um Jiraf and Nasb, and descending the latter valley, two peaks on the left hand or northern side at once attract attention, the one, Gebel Khasib or Ekhma, being a long crest which still has the dark colour due to the felsite capping, but possesses the character of a drawn-out ridge such as is marked in the elevations due to hard dykes. It is thus a transition between the two types above mentioned, but is completely overshadowed by the fine summit of Heza'ima, which rises abruptly as a single precipitous dome of almost Matterhorn-like aspect from amongst the surrounding low hills. The small valley of Wadi Heza'ima, which rises in the Khasib range to the west of this mountain, possesses all the usual features of the boulder-strewn Sinai gullies (hereafter termed boulder-valleys), but is bordered in its upper reaches by precipitous terraces of gravel. On the low rocks occurring at its junction with Nasb are a number of the *nawamis* or bee-hive stone dwellings which were only met with by us in this portion of Eastern Sinai. One of these, which was of small size was opened after first removing the flat granite slab which is always placed on the top of the main construction. Underneath was the skeleton of an ibex, which had probably crept through a small opening in the side of the building. Finally, on sweeping away the

rubble, a number of small cylindrical and ring-like beads were obtained, and a few pieces of very decomposed bone, tending to confirm the view previously expressed by Mr. Holland that these were most probably graves.

Another in very perfect condition lower down was also superficially examined, the central aperture at the top measuring 1 metre diameter having been also covered with a flat stone. The total diameter of the top was 4½ metres, being nearly a complete circle, while the low door which points west is 52 cent. wide and about 85 cent. high, the lintel being about 1 metre in breadth. As the building is on a slope, the lower wall is 1.8 metre high (composed of 7 layers of stone, the lowest consisting of great blocks of granite), while the southern is only 1·55 metre. There is gravel rubble on the top of the flattened wall. From another seen later on, it is evident that all these structures are of the form of truncated bee-hives but not complete, the opening left at the top being covered with a flat granite slab. Close to this spot is a huge granite boulder which might well have been used as a sacrificial stone, and is interesting in connection with a statement made by Dr. Grote (who has been constantly travelling in Sinai, and whom we met in the valley) pointing out the close connection of the word Nasb and the Arabic word for a stone altar, mazba.

After the junction of Wadi Heza'ima with Wadi Nasb, the latter hitherto wide but comparatively uninteresting begins to narrow, the granite foothills closing in on both sides and having a very striking appearance owing to the brightly-coloured red and dark-green dykes which seam the granite in close-set parallel lines. Capt. Palmer thus describes the locality: "The valley narrows from 200 or 250 yards to about as many feet, and then for more than two miles the road winds through one of the most curious and fantastic defiles in the country. The cliffs on either side are of no great height, but they are streaked from top to bottom with countless dykes, almost vertical and of bright varied colours—purple, pink, red, green and black, showing up in well-marked contrast against the dull yellowish-brown of the gneiss, or the sickly green tamarisks in the wadi bed. Some are a few inches, others ten or twelve feet in breadth, some a foot, others sixty feet apart; their numbers are extraordinary and all are very perfect, with hard, shining surfaces. The huge boulders, with smooth, dome-shaped tops and great hollows weathered in their under-sides, which lie piled one on another in wild confusion in the tributary glens of this valley, attract almost as much notice as the dykes. One such mass, of enormous size, at Um Zarabeh, is conspicuous above all the rest, it is a single rock, almost as large as the dome of St. Paul's, and even the smaller boulders

hereabouts are so large that you can walk with ease in the spaces underneath and between them as they rest one on another. The tamarisk grove, which extends for nearly three miles, is said to be, after the Tarfat el Gidarain, the most important in the country."

Just before we enter the deep and rock-bound gorge of Nasb, steep boulder-valleys enter it both from the north and south, that of Abuksheib winding round behind Heza'ima; while on the opposite side Wadi Beidha drains the range of that name. Wadi Threya, a tributary of Abuksheib, had, at the time of our visit, been the scene of a tragedy, a leopard having killed five camels the day before our arrival, but although Capt. Marriott, who was hunting ibex in the district, organized a special search, and the Survey party ascended the station of Gebel Nasb immediately above the spot from opposite sides, nothing was seen of this wily and destructive animal. The gorge itself runs between the spurs of two ranges of very different character, on the south being Gebel Beidha, which from its marked whiteness and massive outlines is one of the most striking of the mountains in this neighbourhood, in spite of its height being less than some of the surrounding crests. Its ascent from the west can be accomplished with much ease owing to the dykes of diabase running up the sides having been worn into grooves, which form natural roads. The summit is very flat, forming an excellent station (hamr, as on Fersh Sheikh el Arab, was abundant), and pools of water lay in hollows, being the result of the heavy storms which had been all round us since crossing the Tarfa pass. Indeed, this portion of our stay was attended with a certain amount of mild excitement as one night a terrific storm burst over the upland districts, and the roar of torrents could be heard every moment increasing in volume. The tents had to be hastily moved, and planted at an inconvenient angle on the slope, but while the higher valleys were swept out by "seils," very little water actually came down Nasb itself, well illustrating the local character of these heavy rainfalls. Here the first evidence was forthcoming of the great dread which the Sinai Arab feels for the dwellers on the opposite coast of the Gulf of Akaba, the sheikh of the expedition stating that he would on no account conduct us to the sea-shore. The only result of this refusal was his replacement a few days later by Ali Suliman, who has previously been favourably referred to.

The northern side of the gorge is bounded by a range running parallel to the general direction of the valley, in reality a long narrow crest due to a hard dyke, but rising into three summits, to which (adopting the Arabic system of naming the hill from the valley which drains it) the names of Nasb, Harban, and Khoseib have been given. Nasb gorge

stands out from among the wild ravines that characterize Sinai owing to the combination of vegetation with the sterner features of precipice and mountain-wall. Graceful tamarisks stand on both sides at its gate, and for several kilometres the path winds amidst a tangled jungle of palms, tamarisks, reeds, and rushes, while higher up some Arabs have made a garden of palms and dug wells, which seem to be placed dangerously in the centre of the main water-course. A few years ago a small stream trickled down the valley, but to-day it is only represented by a few pools, where purple-coloured dragon-flies skim the waters.

Tributary affluents are few and unimportant: From the north comes in the boulder-strewn groove of Harban (with stone buildings perched on the summit of a high terrace at its mouth), from the south the Seil el Beidha, draining from the hill of that name and terminating in one of those steep, smooth waterfall slopes, which so often mark the entry of the smaller feeders into the main valley. To the eastward, the hill becomes lower, and the great peak of Beidha is visible from base to summit.

Other wadis of note enter from the north, viz:—those of Khoseib and El Beagh, which like most of those draining from the hills are wide in their upper portion and narrow as they approach the main valley. There are also a few steep water-courses coming in from the south, viz:— Wadi Abu Sowera, a small boulder-valley bounded by fine cliffs; Krum Harbi, a gully with a pretty group of palms; and Wadi Bukka, having a fine granite basin near its entry into Nasb, which after rain contains a very pure water-supply. Finally, the broad upland expanse of Eggidi, lying at the eastern foot of Beidha, also enters Nasb by a narrow opening, and terminates in a precipitous fall, which renders it inaccessible to camels from this point.

The Nasb ravine is an excellent locality for sportsmen when water is scarce in the hills, as the ibex then come to drink at its water-pools. Capt. Marriott had shot nine of these animals between 18th October and November 6th, obtaining some very good heads.

The gorge broadens out at a point where two valleys enter it from the northern and southern sides respectively, this being the first example of the remarkable *cross-road* junctions of intersecting valleys so common in Eastern Sinai. To the north lies the important artery of Wadi Um Ghirat, which though a continuous depression is, as will be seen from the map, not a valley in the strict sense of the term, but in its lower portion a series of gravel terraces cut across by transverse water-partings. Um Ghirat is of importance also for the local circulation, as it forms an easy route to the plain of Es Senned through Wadi Senned and an alternative route to Dahab through the fine ravine of Wadi Gura.

Wadi Um Ghirat is separated from the Um Beagh drainage by a moderately high range, Gebel Matershat, and has at its junction with Nasb terraces of detrital materials 6 metres high, forming excellent camping-grounds. To the west of these comes in the small feeder of Um Kaimen, bounded by cliffs of gravel exceeding 12 metres in height. At first the road up the valley leads over several small plateaux of a similar nature, covered with rectangular stone buildings and circles, also crossing the drainage systems of Matershat and Kheirait (which cut across Um Ghirat obliquely), but afterwards enters a broader expanse, in which bushes of *retem* (a broom-like bush) and *abeitheran (Artemisia judaica)* are very common. Higher up, the wadi branches into two arms, the main one running to the west of a small dyke range, while to the east the broad Wadi Gasr receives tributaries from the high ground to the east, the most notable being Wadis El Mir and Ashara.

The characteristic feature of this portion of the country is the important part played by the hard dykes in giving rise to drawn-out ridges, running in two directions at right angles to each other. To this origin can be traced the form of most of the ranges in this neighbourhood, viz:—Kheirait, El Mir, Amu Jidid and Um Beda. On the other hand Gebel Serafat between Amu Jidid and Um Beda is in strong contrast to the other ranges, being composed of the characteristically rounded granite slopes.

A low and very easy passage (Haid Merzega) leads from Um Ghirat into Wadi Um Senned, which as a broad ravine bounded by granite cliffs seamed with many dykes, descends from the plain of El Senned to join Wadi Gura. Vegetation is here fairly abundant, consisting chiefly of *abeitheran* and *kebad* (*Zollikoferia*) as well as *aleigan*, a plant with an odoriferous sap.

On the pass of Haid Merzega was a leopard trap. The leopard can just crawl through an opening and immediately on seizing the bait at the same time pulls a string connected with a weight, usually a heavy stone, releasing the latter, which is balanced in such a manner that it falls through an opening, completely barring the exit.

The southern tributary of Nasb, Wadi Um Rachal, is chiefly noticeable for its straight character, the hills on both sides being comparatively low and of very variable structure. Just as in the case of Wadi Wa'era, this valley terminates at the edge of the transverse divide, on the southern side of which is a drop to Wadi Amlagh of several hundred metres. A zigzag path leads down the steep slope, but is readily available for heavily-laden camels. From here the interesting point was noted that the valley on the other side of Amlagh is in the same line as Um Rachal,

although at a much lower level. A long and narrow ridge separates the Eggidi drainage from Um Rachal, which only receives a few unimportant feeders, one of these, Wadi Um Sakran, receiving its name from the abundance of the fox-glove-like purple *Hyoscyamus*.

From the summit of the dyke ridge of Um Kubbath a general idea of this part of the country can be obtained. To the west rise the huge plateau of Abu Mesud and the white dome of Beidha, to the east being many dyke ridges, among which the (apparently) conical peaks of Adakkar, Um Zaimer and El Mir are most conspicuous. To the south stretches the long groove of Wadi Khaiza, bordered on the east by the dark ranges of Harasi and Hamra, and on the west by the precipices of Tha'albi, Abuzag and Nakhara.

Just as on the west only a narrow ridge separates Um Rachal from Eggidi, so on the east a low water-parting alone divides the former from the wide valley of Shethan, which at first a broad plain, narrows as it enters the Ashara range into a wild and impassable gorge, which with an extremely rapid fall opens into the Wadi Shelala subsequently to be described. In its upper part Wadi Shethan is mainly bounded by dyke-hills, here and there being square monastic buildings with low openings. Although numerous side-valleys enter Shethan in its upper part, they are all unimportant; of these, Wadi Hamra has some thick gravel beds and old monastic buildings, and there are palms in Wadi Ashara. The view to the east is bounded by a range, Gebel Ashara, whose jagged and toothed outlines gave every promise of a difficult and exciting ascent. Yet, when its base was reached, there lay before us a broad road (due to a soft diabase dyke), strewn, it is true, with boulders derived from the higher peaks, but presenting no difficulty and leading directly to the summit. The latter proved to be a broad plateau, out of which rose a series of parallel dykes, giving rise to the irregular and saw-like aspect of the mountain when viewed from a distance. This massif occupies the angle between Wadi Nasb and Wadi Shelala, forming precipitous walls which border the former valley on the south.

Returning to the cross-road of Nasb, and descending the latter valley, the scenery once more becomes of imposing character, bold hills scored by wild gorges filled with boulders bounding the deep and narrow ravine, which in part has a flat sandy floor, grooved only by shallow dry water-courses, while at other spots groves of palm trees give an additional touch of beauty. The effect of the contrast is therefore very striking, when at the gates of Nasb the way seems suddenly barred by dark hills of softer outline, the valley turning at right angles to itself in a T-shaped manner. Reference has already been made to the occurrence

(a) RAVINE OF WADI ISLA.

(b) RAVINE OF WADI NASB.

of patches of sandstone along this longitudinal valley, while at the head of Wadi Shelala the same rock now constitutes a barrier between the Nasb and Kyd drainages, forming a cliff over 100 metres high of brilliantly variegated or dazzling white colour. Wadi Shelala and the north-trending bend of Nasb are but parts of a long depression, itself continued to the north in the tributary of Um Raiyig, which enters the latter valley at the point where it again turns north-east. The remarkable character of this rift-valley has already been mentioned, as it runs at first between the dark range of Ferani on the east, and the rugged hills of Ashara on the west, and then for some distance northward between steep bounding walls of granite rising over 500 metres above the valley. From the bend Wadi Nasb is practically one continuous ravine except where tributaries meet it coming in from the north or south, the most important of which is the longitudinal fissure of Wadi Raib. After its junction with the latter, the bounding hills are less steep, and scattered along its course are low hills of friable white sandstone or gravel terraces, the most important of which is a rock over 100 metres high, rising abruptly in the angle formed by the junction of Nasb and Abuksheib.

Finally emerging from the hills, Wadi Nasb, now a shallow water-coursebounded by low cliffs 2 metres high, crosses the narrow peninsula of Dahab, a fringe of palm trees extending across its channel at the point where the valley enters the sea. On the gravel terrace above the valley are a number of ruined buildings of rectangular form.

While the valley itself thus bears witness to tectonic changes of great importance, an ascent of the scarps which bound it reveal the fact that they are but the edges of a granitic plateau which once extended continuously from the Ferani range to the edge of the Nubian sandstone escarpment, and still earlier was covered by the sandstone itself.

To-day it is grooved by valleys, cut through by deep rifts, worn into ridges and basins by differential weathering of hard dyke and soft granite, the result being the production of a number of mountain plateaux bounded by precipitous walls, and towering above wild gorges. Thus it is that Wadi Sa'al, starting its course in a ravine which caused Laborde astonishment by its Cyclopean grandeur, after for a time widening out in the sandstone region, becomes once again a deep cleft as it re-enters the granite, forming the narrow and winding valley of Wadi Hammam. Vegetation, too, is abundant, the most notable of the plants present being *rimth* (*Haloxylon Schweinfurthi*), which has never been collected by us south of the Nasb drainage, the aromatic *abeitheran*, large bushes of *kebad* (*Zollikoferia*), *gurdi* (*Ochradenus*) and *retem*. Here on a small

sandy terrace are a number of *ausedj*, a little further a grove of tamarisk forms a graceful picture under the shadow of the red granite cliff. The side-valleys terminate in many cases in sharp drops, or *seils*, broadening out above into wild plateaux where *theman* (*Peganum*) and *kebad* are present in great abundance. Ants, extending in long lines, traverse the valleys from side to side, partridges call from among the rocks, and hares evidently are of common occurrence, judging from the traces of their forms under the bushes. Finally, a small group of palms, only visible from the higher summits, is hidden away in the deepest part of the glen.

The plateau character is most marked on the eastern side of the hill-region lying between Wadis Um Raiyig and Ra'ib, the northern plateau above Abu Somra being capped by a number of flat-topped outliers of Nubian sandstone. Yet even here the differential weathering of the dykes gives rise to isolated summits, which generally receive their names from the valleys which drain their slopes. Five peaks are more striking than the others in this neighbourhood, viz:—Abu Somra and Gebel Ushtan, both dyke ridges, the twin hills of El Araish and Abu Thugutan, and the great yellow dome of El Rai'emshi, which at once strikes the eye from every point of vantage.

The country between Wadi Nasb and the Ferani range is again a high plateau ending in steep slopes over 300 metres above valley level, but is less deeply scored than the country previously described, the dykes, however, being very numerous. Most of the valleys rise in a broad expanse (generally known to the Arabs as a *fersh*), surrounded by hills of no great height, the most prominent of these being the Fersh El Hamra, situated at the northern foot of a high spur running from the Ferani range. The drainage of this region runs north, east and west, on the south being a mountain wall which rises steeply above the granitic country, formed by the cone of Abu Mesa'ud and the long crest of Um Shoka el Kebir. The principal mountain valleys, however, all trend northward and eastward, entering the Nasb gorge; they present the usual boulder-strewn character, but in addition the wadis of Sadagiya, Gurna and Um Hargel all contain palms. The latter receives its name from the abundance of the *hargel* bush (*Gomphocarpus fruticosus*) which was fruiting at the time, the greenish-yellow pear-shaped fruit being everywhere abundant. Most of these valleys, as well as the smaller water-courses, are characterized by the comparative richness of the vegetation, consisting mainly of *kebad* (*Zollikoferia*). They descend as broad gravelly channels between the ridges, but as they approach the edge of the scarp above Wadi Nasb narrow rapidly, finally terminating

in steep water-courses full of couloirs, often completely smoothed and polished. In fact, while the ascent of the hills was seldom difficult, the descent was not infrequently attended with a certain amount of risk if many of these dry waterfall beds had to be negociated. As is seen from an examination of the map, the whole granitic district is now broken up into a series of steep-sided table-lands, one of these, west of Gebel Gurna, being entirely cut off by three deep valleys from the remaining portion of the country.

After the junction of Nasb with Wadi Raib, the hills between the former valley and Um Shoka rise into three prominent peaks as described below, these being on the boundary of the felsitic and granitic rocks. Wadi Nasb is here characterized by the local abundance of *rimth* (*Haloxylon*) associated with bushes of *sommu* (*Cleome*), *harra* and *dafara* (*Iphiona*), a few seyal trees, and large senna plants. As has already been stated a very characteristic feature is the presence of white sandstone and gravel ridges in the valley, the most notable of these, over 100 metres high, filling the angle between Abuksheib and Nasb.

The three summits above-mentioned are the conical Um Shoka, the long north and south trending ridge of Hamra, and Jeraimda, which with its smooth granite slopes is very conspicuous from the seaward side, while in a little secluded valley on its northern flank nestles a small palm-grove of much beauty. These hills, ranging from 800 to 900 metres in height, separate the main Nasb drainage from that of the Abuksheib system, which receives its main feeders from the Ferani range.

Ferani range.—The latter is undoubtedly one of the finest mountain masses on the eastern side of the peninsula, the deep ravines by which it is furrowed being bounded by precipices seamed with *couloirs* of forbidding character, their floor being a confused heap of pebbles and boulders rolled down from the heights above. The nature of this range will be best understood from the fact that to map it required five successive ascents of or over 1000 metres.

The main chain of Ferani is remarkably flat at the summit, being apparently originally a plateau which has been cut off both to east and west by two of the rifts previously referred to, while to the south it is naturally bounded by the transverse valley of Sai'amin, and to the north terminates in the high rock-wall of Um Shoka El Kebir. The uniformity of the high plateau is best shown by reference to the height of the principal peaks, these being as follows (in metres): Um Aleg or

Halla (1,500), Ma'in (1,630), Zaraga (1,650), Ferani (1,520), Um Shoka El Kebir (1,390), and Lij (1,440). Um Aleg and Ma'in especially show the flat table-land character, the effect being very striking when, after a weary climb up boulder-gullies or round precipitous corners, one suddenly emerges on a smooth plain or undulating plateau, which on every side is bounded by deep ravines and precipices. Nor is vegetation by any means scarce, the summit of Um Aleg being quite white with the dried bushes of *hamr* (*Anabasis setigera*), which is one of the commonest of the hill plants in Sinai.

The northern portion of the range is drained by two deep mountain valleys, one of which, Um Athaga, is part of a longitudinal rift, while Um Harag cuts transversely across it. Um Athaga presents no special features of interest, being simply a fairly wide valley bordered by high ridges and connected with Wadi Lij by a low pass. Gebel Lij, the highest summit of the range to the west, is very steep-sided and is seamed by boulder-valleys, descending in a series of rock-steps which at times are difficult to climb. In descending the main drainage-line from the summit, a smooth shoot or *couloir*, over 30 metres in height, made further advance in that direction absolutely impossible, a tunnel worn under a boulder fortunately enabling the obstacle to be rounded with a less vertical drop. Notwithstanding these steep slopes, the summit itself is comparatively flat, though out of it rise boulder-strewn ridges of granite, forming fine precipices where they constitute the boundary of the scarp, and continuing for long distances as the edges of well-marked crests. It is also remarkable to find some stone-circles, one of them nearly 8-shaped, in a small hollow in the top of the mountain, in a place which from its isolation it seems impossible to imagine could have been chosen for purposes of habitation, or even burial. It seems far more probable that these represent the "high places" of the ancient peoples inhabiting the country, resembling as they do the circles to which M. Maspero assigns such an origin in his great work on the "Dawn of Civilisation." Here again *hamr* is the most widely distributed of the plants.

The valley of Um Harag, descending between the spurs of Zaraga, Ferani and Abuksheib, is far wilder than Um Athaga, and for part of its course, before it leaves the main mountain mass, forms a grand ravine, whose rocky walls rise abruptly above the boulder-strewn water-course. In its upper part it widens out, many bushes of *lassaf* (*Capparis spinosa*), with their large bright-green leaves, softening to some extent the bareness of the scene.

It is not surprising to find that leopards here have a congenial home,

one of these animals being seen by a bearer on the return from Zaraga, while in the morning their foot-prints were all round the camp, the leopards probably having been attracted thither by the presence of a dog, which kept up a continual howl all night.

In general, it may be said of the Ferani range that its summits consist of gently-undulating hills and valley-basins, terminating at the edges of precipitous slopes. Stone-circles are by no means limited to Lij, but are also present on the plateaux near the highest peak, i.e., Zaraga.

At the point where the united valleys of Abuksheib, Um Harag and Um Athaga issue from the main range, a well-marked gravel terrace with a perfectly flat surface forms a conspicuous object, while the valley is strewn with boulders of every shape and size, the camels having to find their way along the deeper water-courses.

Soon after leaving the mountains, Wadi Abuksheib passes from the dark felsite region into the lower granitic country, the dark-green ridges formed by the first-named being replaced by the light-coloured slopes characteristic of the granite areas. Two tributaries, both bearing the name of Wadi Ma'in, drain from a higher range to the west and the lower country to the east, the watershed being formed by some granite knolls. The long crest of Gebel Ma'in and Um Et Wejera is of some topographical interest, as it is drawn out parallel to the direction of the longitudinal rifts, and at the same time being formed of felsites above and granites at the base shows a contrast both in structure and colour. The ridge is seamed by numerous watercourses, there being also a few pools in one of these, where the valley is broken by a series of precipitous steps. While its western slopes descend steeply to Wadi Um Athaga, on the east there are some very marked gravel ridges, which seem to have been formed owing to the holding back of the detrital materials descending from the hills by dykes in the granite. Numerous stone-circles were met with in this neighbourhood.

Wadi Abuksheib receives another large tributary from the west, Wadi Um Shoka, formed by the union of three branches, two of which rise almost on the edge of the Nasb rift. One of these rises in the plateau basin of Fersh El Hamra and receives all the drainage of the mountain wall of Um Shoka El Kebir, while the other equally has its origin in a broad *fersh*, Fersh El Abuksheib, over a thousand metres above sea-level. Wadis Abuksheib and Um Shoka have their origin in this plateau, rapidly narrowing as they descend, and giving rise to wild and rocky gorges, where small smooth stretches, bounded by rock-walls and studded with bushes, are succeeded by steep rock-steps, or worse still,

smooth-sided, steep-angled *couloirs* down which the storm waters must form magnificent cascades after heavy rains.

Where Um Shoka broadens out, one of these mountain tributaries terminates in a rocky precipice some 6 metres high, having at its foot a band of conglomerate and a large hole, which is a splendid collecting-ground for water, though at the time of our visit it was almost dry. Were this depression filled, the water would be nearly two metres deep. Above the rocky step are many pools fringed by reeds where leopards, ibex and coneys are numerous, judging from the tracks. The wild fig or *lassaf* (*Capparis spinosa*) is extremely abundant in these granite gorges, and in the main wadi is a stone-circle near the head of the pass.

The mountain-walls bordering Um Shoka on the south are particularly wild and forbidding, the crests often being only thin knife-edges bounded by precipices on both sides. Here on one occasion, having lingered behind to examine an inlet of Nubian sandstone, I discovered one of our younger Arabs wandering among the cliffs, which here descend in a series of steps, and pathetically exclaiming that Skill and the others had been like ibex, and gone by a ridge where he dared not follow. The latter was certainly not devoid of difficulty, but as a rule we found that it was better to keep to the highest portion of the ridge whenever possible, as on the lower slopes steep rolling talus directly overhang cliffs where a fall would have serious results. While trying to find his way out, the Arab above-mentioned secured a young ibex, which unfortunately died two days later.

Before entering Nasb, Abuksheib receives the wide valley of Tellat Unsair, on both sides of which rise the narrow-crested granitic ridges of Um Isma and Tellat Unsair (635 and 510 metres respectively), wild fig (*lassaf*) being especially abundant in the gorges descending from the latter range. To the north of Um Shoka and Abuksheib, the mountains terminate in the prominent dome of Jeraimda, rising 833 metres above sea-level.

Gnai amphitheatre.—Between the Ferani range and Dahab lies a small region having a drainage system independent of those of the valleys of Nasb and Kyd, and owing its origin to the tectonic movements previously described. On the south it is bounded by the transverse divide, and on the west by the advance-guard of the Ferani range (El Wejera, etc.), on the north only a few low passes marking the separation from the Nasb system. The transverse divide at this point itself consists of a fine series of granitic hills, rising in Gebel Gnai

and Gebel Um Malaga to 1055 and 1215 metres respectively, the former especially forming a striking feature when seen from the central ranges owing to its smooth outlines and pink colour.

This district was first entered from the south, a fairly steep pass, the Sharafa, leading from Wadi Melhadge into Wadi Gnai, both these valleys being enclosed between steep ridges in a rift-like manner. Wadi Gnai is bounded on the west by the typical granitic ranges of Gnethel and Beidha; on the east the hills are lower and darker-coloured, but finally these are reduced to a thin strip behind which rises the imposing summit of Gnai. Wadi Gnai receives a few tributaries in its course, one of these, Wadi Gnethel, having some terraces at its head, on which are a number of stone-dwellings, five of them being of the rectangular type and the remainder stone-circles. One of these was still in excellent preservation, the stones being heaped up in such a manner as to form a narrow chamber, in which a man of medium size could lie extended, the opening also being of sufficient area to admit of entry.

In the main valley a noticeable feature is the abundance of the fleshy-leaved *ashara* (*Calotropis procera*), while among the minor plants *Zilla* is very abundant. In addition, a large *markh* (*Leptadenia*) bush, covered with hornets, and a bright dandelion-like composite, the *Numwerta hawa* of the natives, were noted. While the main valley is fairly rich in vegetation, the smaller tributaries are much more so, and in Wadi Hamra, near the foot of Gnai, among the large blocks which filled its course, were scattered bushes of *Artemisia*, *Zollikoferia* and *ghassah* (*Otostegia*) a few *lassaf*, and at the base of the mountain straggling bushes of *chibrim* (*Convolvulus hystrix*) not previously observed. Nor is vegetation restricted to the wadis, the shallow depression between the crests of Gebel Gnai being crowded with bushes of *jeradeh* (*Teucrium?*). *Seyal* trees are also frequently met with near the base of the mountain ranges. After a northward course of several kilometres Wadi Gnai bends sharply to the east, and becomes a wild and impassable ravine, Wadi Gnai El Rean (plentiful), so called from the presence of numerous water-pools, in contrast to Wadi Gnai El Atshan (thirsty), the other valley draining this limited region. These small pools are usually hidden among the side-valleys and are accompanied by palm-groves, whose bright-green tints, in sharp contrast to the red granite, form pictures of exceptional beauty.

The other valleys which drain into Wadi Gnai El Rean are small feeders descending from the granite ranges of Um Malaga and Ma'in, while the region lying between the hill amphitheatre and the sea is filled with low dyke ridges forming fairly conspicuous summits in Gebels

Tellat Sorar (745 metres) and Madjura (645 metres). These dykes are of two kinds, giving rise to corresponding differences of scenery, those of red felsite being noticeable at the head of Wadi Um Geyra, while between the summit of Madjura and the valley of Seyal Noma, ten dark bands seam the mountain side, and are continued across to the Um Malaga range. Altogether there are more than 25 principal dykes in a limited space, all parallel to one another, and some of them being over 30 metres wide. Crossing a low watershed, the drainage of Gnai el Atshan is entered by the valley of Seyal Noma, which receives its name from the abundance of *Acacia seyal*, this tree being associated with *Iphiona scabra*, *Zilla* and *Zollikoferia spinosa* as the chief vegetation, *Shouwia arabica* being also present. In the neighbouring valley of Tellat Sorar is a beautiful grove of seyal trees, there being more than forty close together. Wild ravines descend from the neighbouring hills, and it is no unusual occurrence to find remains of ibex killed by the leopards which appear to abound, though never seen. At the mouth of Wadi Gnai el Atshan the track suddenly opens out into a narrow plain only a few hundred metres broad, rapidly narrowing southward, while to the north it broadens out into the Dahab peninsula. To the south this expanse is bounded on the west by a knife-edge range rising in precipitous slopes, while the plain is dotted over with circular straggling bushes of bright green *araka* (*Salvadora persica*) and *gharqad* (*Nitraria retusa*). The latter at evening time are surrounded by hundreds of shells of *Dolium*, *Canarium*, etc., all apparently on the move, and producing a rustling sound. Close examination shows that the curious phenomenon is due to the presence of hermit-crabs, carrying about with them their borrowed homes, and come to feed on the sweet red berry which forms the fruit of this plant. A narrow band of vegetation fringes the shore of the Gulf of Akaba, consisting of stunted palms, rushes and a zygophyllum, in addition to the above-named bushes, while seaward stretches a narrow shelf of coral-reef over which the surf is continually breaking; where it stops abruptly, the water is of an intense blue colour, and it has been ascertained by sounding that the gulf itself is of great depth at this point. The sea-beach is composed of rounded pebbles, and it is evident that the Dahab peninsula is merely coral-reef flanking the granite hills, over which detrital material has been subsequently spread by streams, etc. Immediately beyond this beach is the living coral-reef, mainly consisting of madrepores and *Pocillipora*.

Approaching Dahab these features disappear, and opposite the

DYKE RIDGES OF MOGHTUT.

incurved promontory of the peninsula, sand-dunes line the shore, having been formed round the *Nitraria* bushes; these in turn are succeeded by a raised platform, covered with shells of the *Strombus fasciatus* zone. Still nearer the gulf the shells are very much polished, and specimens of the striking-looking, irregular sea-urchin *Lovenia* were present, this being the only spot where they have been noted in Eastern Sinai. Between the shore and the promontory above-mentioned is a shallow lagoon, covered with salt, through which rise knolls of black rock, apparently a limestone. At the extreme end of the point is a small lake, completely surrounded by raised beach, and bordered by similar black hackly rock, about ·03 metres thick, consisting almost entirely of oysters and igneous pebbles cemented together by a calcareous cement. Above this is a *Mytilus* bed, these shells being associated with the flattened petaloid sea-urchin *Lovenia;* finally at the cape itself, the beach above the sea is covered with shells of *Tridacna* and fragments of coral, the shore-line of the lagoon, but recently dry, being outlined by innumerable shells of a small *Cerithium* (*Pirenella*).

Dahab or Kara Bay has deeply indented the Dahab peninsula at its southern end, and there is fair anchorage in the deep water close to the shore. But the most characteristic feature of the peninsula is the presence of three large groves of palms situated close to the shore, the central one extending across the dry channel of Wadi Nasb; these date-palms belong to the Emzeina Arabs, and at the period of harvest all the owners assemble for the gathering of the fruit, bivouacking in booths made of straw, which apparently remain from year to year. Dahab is also notable for the presence of two important wells of ancient date, these being dug in the raised beach; of these the southern, that of Mishraba, is an inverted conical hole about 2 metres deep, lined with boulders and coral, while four thick palm-trees are disposed in rectangular fashion at the surface. The palm-grove near by is carefully tended and laid out in small plots, while in front extends the reef, a calcareous platform barely covered by the sea, in the interstices of which hundreds of starfish find a home. Here an old fisherman was met with engaged in spearing cuttle-fish, and apparently the sole inhabitant of the district at the time of our visit. There seems no reason why any number of wells should not be dug here, and palms planted along the whole border of the peninsula, there being some reason why these groves grow especially well close to the sea-shore.

A second small bay, that of Gahaza, breaks the regular outline of the eastern border of the peninsula, and is of interest because it exactly occupies the mouth of Wadi Nasb; as has been suggested elsewhere,

its presence may be due either to the unfavourable influence of the materials brought down from the hills by the rainstorms on the growth of the coral-reef, or to a secondary depression of small extent which has caused the sea to advance up the valley.

After the northern palm-grove is passed, the plain rapidly narrows until finally only a thin strip of low-lying land is present between the granitic foothills and the sea. It consists of four distinct raised beaches, the one with large shells (*Pteroceras*, etc.) being the most conspicuous, while that with *Strombus fasciatus*, etc., was only slightly developed. The abundance of large-sized sea-urchins is also a noticeable feature, these including most of the typical Erythræan forms, such as *Heterocentrotus*, *Phyllacanthus*, and *Brissus*. In some places a distinct calcareous boulder floor had been formed, which having been slightly raised above sea-level has given rise to a low undercut cliff, against which the sea is constantly breaking in sheets of foam. Aquaria full of the most varied life are everywhere abundant, in one of these pools is to be seen a clump of corals, in another chitons and barnacles abound, while at one spot a remarkable fish, with its pectoral fin broadened out, seemed to slide along the rocks. Unfortunately it disappeared in a water-swept fissure, rendering its capture impossible. Thick boulder gravels also rest on the slopes of the much-decomposed granitic foothills, and one of these cemented by calcareous material was noted lying on the summit of a diabase cliff 80 metres above sea-level. To the extreme north of the peninsula is a conspicuous white cliff, which on examination proved to be a raised reef, resting on a gravel derived from granite, and which near the point of junction is full of large boulders of the igneous rocks of the district.

The hill country at the back of the peninsula to the north of Wadi Nasb is similar to that on the south of the valley, its characteristics being briefly as follows:—A series of well-marked black ridges are produced by the dolerite and felsite dykes which run parallel to one another across the country. Between these are light-coloured steep slopes of granite, rendered very slippery by the presence of a thin layer of quartz, felspar, etc., due to the decomposition of the underlying rock. A noticeable feature is the almost canôn-like nature of the numerous small gorges, which seam the sides of the hills, owing their origin partly to the small amount of rainfall and partly to the denudation of basic veins, which are often seen to form the base of these ravines. The bottom of the gorge usually consists of long stretches of smooth, sandy valley (containing abundant vegetation), which suddenly terminate in abrupt rock-falls, from the base of which it

again resumes its previous character. If a diabase dyke be present, the steps are often easy of ascent, but if the rock be of a harder nature, it is necessary in most cases to retrace one's steps and mount the hill-face, so as to round the obstacle, which usually stretches across the ravine from wall to wall. The presence of these drops often rendered the return from the day's work somewhat exciting, as they present a considerable element of danger after nightfall.

While the main portion of Dahab peninsula is a plain, Wadi Dahab is bounded on both sides by a terrace of coarse gravel 2 metres high, on which (to the south) are a number of ruined buildings, most of them rectangular in form. A second terrace lies against the foothills, the boulders in which are much larger (over ·3 of a metre), and it is interesting to note that they are not only of coarse granite, such as would come from the neighbouring hills, but also include syenite and types of felsite which could only have been brought from the Ferani range. The vegetation mainly consists of *rimth* (*Haloxylon*) which is very abundant, and the grass *theman* (*Panicum turgidum*), while *dafara* (*Iphiona scabra*) is found more frequently up the side valleys in the hills themselves.

Region between coast-range and Gulf of Akaba.—It has already been remarked that a comparatively high range of hills forms a line of watershed which runs parallel with the gulf. Leaving the camp standing near Dahab, a rapid traverse was made along the shore-line to map in this region, which probably has not been previously visited, Holland having abandoned the attempt to do so. Immediately beyond the mouth of Wadi Gnai El Rean the plain narrows rapidly, the mountains descending to the water's edge in such a manner that only a narrow coral platform separates them from the sea. The hills themselves are of a threefold character, each type forming the front of the range in succession. 1. At first the light highly quartzose granite similar to that of the Gnai range is the principal member of the knife-edge ridges which extend nearly as far as Wadi Waira, these being succeeded in turn by 2. A darker group, the rocks in which show a distinct massive banding, and are mainly biotite-gneisses or hornblende-syenites. 3. At the mouth of Wadi Waira these are replaced by red and grey finely-banded gneisses. The granite forms sharp summits difficult of ascent near its junction with No. 2, and the dolerite dykes at this point are also very clearly marked.

To the southward a track suitable for lightly-laden camels runs over a raised reef resembling a most carefully prepared road of gneiss pebbles

cemented by calcareous material; where it faces the sea, forming a low undercut cliff, this raised reef alternates with stretches of raised beach strewn with large shells of *Tridacna*, *Strombus*, *Fasciolaria*, *Conus*, *Cypræa*, together with *Fungidæ* and corals of various descriptions. A noticeable feature is the heaping together of broken shells of a large *Trochus* or *Turbo*, possibly brought together by birds who may have selected these spots as their feeding-grounds. At one point the sea, at high tide or during storms, washes the foot of the hills themselves, where the camels have to be led over a difficult path, while further south beyond Wadi Um Tarfa the passage is absolutely barred.

Turning to the hills, it will be easily seen from the map that there are spurs projecting at right angles from the north-and-south-trending coastal-range, being separated from each other by narrow ravines often terminating towards the sea in precipitous drops such as have been previously mentioned.

Whether ascending Wadis Mowila, Sajerat or Um Ekhmoil, the same geological succession is observed, the now quartzose hornblende granite (with large sphene) being succeeded by grey or very broken red gneisses, which are often brightly coloured, the alternating green and red bands forcibly recalling the alternation of the felsite and dolerite dykes observed elsewhere. Although, taken as a whole, the ravines are sufficiently wild and forbidding, in places there are many seyal trees and some very pretty palm groves, notably in Wadi Sajerat, where in addition to the date-palms, pools of water, tamarisks and reeds with their bright-green tints, refresh the traveller who grows weary of the constant view of bare peak and stern desolation. The water unfortunately is brackish, a large amount of salt being deposited near the pools and on the diabase dykes in the neighbourhood. It is scarcely to be expected that this region, hidden behind rugged barriers, is likely to be frequently visited, but any traveller passing through Dahab would find this journey one of considerable interest. It will be noted that the Arabs have a name for every one of these out-of-the-way valleys, the palms in all cases belonging to definite groups of owners, who visit them at the date season to gather the fruit.

The coastal range itself was ascended from the western or Wadi Melhadge side, the most important mountain of the group being Gebel Abu Esherat (1125 metres), which is a species of minute Matterhorn, a sharp tooth of extremely precipitous character rising from the main crest. Looked at from below it seemed impossible to reach the summit, but following the rule adopted to attack every peak required as a station, and only to abandon it when every reasonable effort had been made,

(a) COAST RANGE (GULF OF AKABA).

(b) SHORES OF GULF OF AKABA.

the ascent proved of no exceptional difficulty, a fissure in the side of the precipice forming a natural path to the summit. At one point near the foot of the final ridge a boulder had been wedged in in an overhanging manner, forming an obstacle which did not prove formidable. The remaining characteristics of the coast-range will be treated under the Wadi Kyd section (see p. 72).

Wadi Kyd and its tributaries.—Wadi Kyd, as before stated, takes its rise in a basin-shaped depression, the Fera el Adhal, from which it is the only outlet, the valley forming a remarkably narrow ravine (from the side visited by the expedition apparently untraversible). Interesting as it would have been to have traced it to its commencement, the fact that the whole district had already been mapped from the summits commanding it, did not justify giving time to a point of detail, especially as Holland has already described the locality. The Fera el Adhal is bounded on all sides by the steep slopes of mountains, most of which rise at least 1000 metres above it, and owing to the abrupt character of the scarps, it can only be entered (apart from Wadi Kyd) by a narrow zigzag pass descending from the high ground behind Gebel Hadid. Wadi Kyd itself is reputed to be one of the most fertile spots in the southern end of the peninsula, and several of our Arabs acting as camel-men were owners of vines, palms, figs and nebk trees hidden away in this secluded glen. At the eastern end of the ravine a small running stream and many bushes of *lassaf* or wild fig give a touch of beauty to the scene, in sharp contrast to the boulder-strewn and desolate valley of Wady Umkheizen entering it from the south. Wadi Kyd now broadens out into a wide expanse containing numerous seyal trees, and is bounded on the north by the dark-green hills of Handar and Eth Themila and the pink ranges of Gazala, on the south being the foothills of Um Hashim. *Zilla* and *kebad* were abundant on the mountain sides, while in Wadi el Ghim, which joins Wadi Kyd from the north, *dafara* and *natesh* were common, the former being very green. Close to this junction there is a sharp line of demarcation between the granitic and schistose hills, while from the south enters one of the principal side branches, Wadi Um Gerat, itself formed by the union of the three important mountain valleys of Humr, Ethmid and Jendeli, which will next be considered.

Wadi Um Gerat.—Wadi Um Gerat follows the usual rule noted in these Sinai valleys, being bounded on both sides by the foothills of granitic ranges which rise in tier upon tier, both to the north and south, terminating in abrupt scarps or forbidding precipices, while the mountains are deeply scored with narrow and sinuous ravines filled with huge

boulders rolled down from the slopes above. The valley itself, on the contrary, has a smooth, even surface, and viewed from above looks like some calm and peaceful river, here and there scent-laden bushes of hargel (*Gomphocarpus fruticosus*) being a resting place for the praying mantis and other insects. But perhaps what will strike the traveller most forcibly is the remarkable banding of the gneissose rock which bounds this valley for the greater portion of its length, great masses of a granitoid gneiss alternating and interdigitating with dark mica- and hornblende-schists. The hills bounding Um Gerat consist of a series of wedge-like slopes, running both north-east and north-west, and at very variable angles to each other. At the southern bend the ordinary biotite-granite apparently overlies the schists, being often rich in mica, very friable and containing quartz veins, which have been much folded and fractured. Large dykes of a basic felsite also cut across one another on the western slopes.

Having camped on a marked gravel terrace at the foot of the boulder-valley of Abu Marua, Gebel Geraui (1695 metres), which rises 880 metres above the valley and is composed of schists and gneisses, was ascended from its southern side. It is seamed by quartz-felsite ridges which give rise to precipitous slopes where they meet the smaller gullies. It is needless to describe each ascent in detail, they usually begin with a scramble up some boulder-valley, then it may be, the rounding of some precipitous slope where a sharp rock step renders the gully of no further use. Usually the difficulties are most marked in the lower slopes, and though dangerous climbing in the mountaineer's acceptation of the term does not exist, it is nevertheless matter for thankfulness that no serious accidents occurred during the 150 odd ascents carried out in this portion of the peninsula.

The crests themselves owe their long drawn-out form to the presence of felsitic dykes which, as has been repeatedly stated, play so important a part in the structure of the peninsula. Of these the crests of Gebel Geraui, Mazea and Marua are more or less parallel, while Asafia is at an obtuse angle. The descent of this mountain was made by Wadi Geraui, a small mountain valley characterized by the presence of some fine waterpools. The broad valley of Wadi Jendeli entering Um Gerat from the south is distinguished by the abundance of its vegetation, *Retem*, *Zilla*, *Zollikoferia*, *Capparis* (wild fig), *Cleome*, *Lycium arabicum*, *Gomphocarpus*, *Artemisia*, *Hyoscyamus* and *Otostegia* being amongst the prevalent genera. At its southern end a pass, suitable for riding camels only, leads into Wadi Um Metir, and is thus a short cut into the Um Adowi area. One of the most notable scenic features in

this wadi is the abundance of dykes, both dioritic, quartz-felsitic and coarse granitic; having usually a north-east and south-west trend, though many cut each other at acute or even right angles. The acid types usually produce the sharpest ridges, but the dioritic masses are also very conspicuous.

Gebel Taibekh. — Already from Abu Mesud, a huge light-coloured granitic mass standing in front of the mountain wall of Halefia had been specially noticed, and its ascent provided one of the worst corners hitherto met with, the track leading for some metres on a ledge 15 metres above a ravine, with a foothold scarcely the width of a boot. The chief danger lay in the crumbling character of these granitic shelves and the entire absence of handhold in case they broke away. The mountain can be easily ascended from another side, but obviously in these great mountain masses it is impossible to say beforehand which of the ravines seaming the sides are likely to be most helpful. Taibekh, together with the still higher summit of Sahasia behind it, consists of biotite-granite or gneiss, this rock being traversed by two systems of dark dioritic veins nearly at right angles to one another, while in addition the gneiss is traversed by a coarse pegmatite.

Gebel Genaui. — On the opposite or eastern side of Wadi Jendeli is Gebel Genaui (1570 metres), the ascent of which is greatly facilitated by a path evidently well known to the Arabs, which leads finally on to a wide plateau at the foot of the main peak. Here Wadi Gasab takes its rise, and it is curious to find the ruins of many stone circles in this isolated region, whose presence was connected by our guide with a period when the rainfall had been much greater. This idea of a greater rainfall in past times seems to be a well-established tradition among the Sinai Arabs.

Ibex were very abundant on the mountain-side, seven being seen in the course of the ascent, including two fine males. The whole of Gebel Genaui and all the lower hills between it and Wadi Um Arat appear to be formed of biotite-gneiss readily decomposing, and traversed by veins of coarse red granite and diorite, the latter being parallel to the ridge running south from Genaui, while some of the more acid cross at an acute angle.

Wadi Humr. — Wadi Humr rises in the lowest part of the watershed between Gebels Humr and Tellat el Gimal and is bounded on both sides by ranges near or over 2000 metres high. Of these Asafia and Mazea

were ascended, the two summits being separated by a broad upland plateau, the Fersh Abu Kharub Um Asafia ; a number of mountain plants were met with, including myrrh, hamr (*Anabasis setifera*), *Gypsophila* and *djahis*. This is the only locality where an umbellifer has been found during the expedition, one of the men bringing in a specimen of *kalth*, recognised by Dr. Schweinfurth as *Zozimia absinthifolia*. On Mazea are ridges of darker diorite veins which appear to have a general trend somewhat different from the conspicuous north-east and south-west ridges of deep red-coloured quartz-felsite already mentioned as being so conspicuous in the hills of Tarfa, Tellat Gimal, Geraui, etc. These become still more prominent in the Humr range, where they occur as huge black bands seaming the light granite or gneiss.

Wadi Ethmid. — Wadi Ethmid is one of the wildest spots in the whole peninsula, a deep ravine filled with terraces of huge boulders, and surrounded by mountains all exceeding 2000 metres in height, terminating in frowning cliffs or talus-slopes of the most forbidding description. It was fortunate for the purposes of the survey that it was not necessary to ascend Eth Thebt from this side, the southern mountain face being apparently a series of ledge-like precipices. Holland found the ascent long and dangerous owing to rolling stones, though he took the far easier road to the north; as in addition the shortness of the winter evening would have forced us to sleep out on the summit at temperatures below freezing-point, the ascent was not attempted, and as stated above, was not required by the work. The magnificent amphitheatre was mapped from the central ridge of Maharrama, itself 1833 metres high, and standing in front of Gebel Halefia, which is not much lower than Eth Thebt, and from a distance is always seen as a long ridge immediately south of that mountain. There is no break between the Humr and Sabbagh passes, without climbing which even in the higher sense might fairly be termed dangerous, but more from rolling stones than lack of points to hold on to. It is probable that these ranges are composed of red granite, and thus differ from those in front, which mainly consist of light biotite-granite or gneiss, and whose summits weather in rounded outlines.

Returning to the junction of Wadis Kyd and Um Gerat, the former now enters a region of sombre hills through which it passes as a bright streak, the granitic detritus giving it a reddish tinge forming an absolute contrast to its dark surroundings. This difference of tint is well shown where the two broad valleys of Ethmoi and Um Zerig join in from

the north and south respectively; standing on the rock ridge which projects forward from the main range at the junction with Ethmoi, the floor of the latter valley is seen to be of a dull-green colour, and only lines of stunted bushes follow the shallow drainages. Wadi Kyd, on the other hand, with its bright tints and comparatively plentiful vegetation, is a welcome sight after a long sojourn among the schistose hills. While speaking generally, the scenery in this schistose region is far tamer than in the granite and gneiss country, precipice and abrupt slopes are by no means absent, and Gebel Ethmoi has a formidable aspect when viewed from the valley, towering in fine castellated ridges above deep gullies seaming its sides. Here ibex seem to find an especially desirable home, as ten of them were seen at one time.

A little further to the east, Wadi Kyd receives Wadi Melhadge from the north, this valley being part of a drainage system having the most complicated twistings and windings. Not far from its junction with Wadi Kyd, the latter is joined by Wadi Madsus, which is itself formed by the union of Wadis Amlagh, Adakkar and Saiamin.

Wadi Amlagh. — Wadi Amlagh takes its rise in the low granite region between the Abu Mesud plateau and Gebel Beidha, Wadi Sheger entering it from the former range, and containing a number of good waterpools, similar reservoirs being present in the ravines descending from Gebel Tha'albi. A steep valley entering from the north leads up to an easy pass into Wadi Um Rachal, the level of which is far higher than that of Wadi Amlagh itself. On the southern side Wadi Khaiza debouches exactly opposite Um Rachal, and as has been stated previously, appears to be part of a rift system. These *cross-roads* are very familiar features in this portion of Sinai, and may be regarded as resulting from the intersection of two fracture-systems running almost at right angles to each other, the valleys in most cases being bounded by very abrupt mountain walls. Wadi Khaiza is no exception to this rule, the gentler slopes of the schistose Harasi and Hamra ranges being faced by the precipices of Tha'albi, Abuzag and Nakhara, which are only the edges of the Abu Mesud plateau. From this point Wadi Amlagh continues in an almost straight line eastward to the Wadi Madsus, only receiving unimportant tributaries, except where it crosses the Nasb-Um Raiyig rift, a broad valley joining it from the north, while a small watershed separates it from a drainage-line of similar nature on the south.

Wadi Adakkar. — This valley, which rises in the slopes of the hill of that name, is similar to Wadi Amlagh, and almost parallel to it.

From the north, when crossing the Nasb rift line, it receives the great Rahab feeder, while it is separated from the continuation of the depression by a low watershed. After passing between hills of gneiss, it enters the schistose region and soon joins Wadi Madsus. In the latter part of its course vegetation is almost entirely absent, but in the gneissose area, *harra* (*Diplotaxis harra*) is by no means uncommon.

Wadi Rahab. — The Wadi Rahab is distinguished from most of the valleys in this portion of the peninsula by its width and the abundance of its vegetation, such favourite camel-foods as *Crotalaria*, *Caroxylon* and *Zilla* being abundant. *Seyal* trees are also numerous in its upper reaches, especially where Wadi Sai'amin branches off from it and pierces the hill ranges. The latter present the most varied forms, owing to the superior resisting power of the innumerable dykes of quartz and syenite-felsites which seam the coarse diorite or finer grained biotite-granite of this region, while blocks of these harder rocks are strewn at the mouth of every small ravine which opens into the valley. Amongst these a spherulitic felsite and red porphyry were very conspicuous, and both were subsequently found *in situ* as dykes near the summit of Gebel Um Zaimer. As regards animal life, dragon-flies of large size were particularly abundant in Wadi Rahab.

A general examination of all the hills in this neighbourhood leads to but one conclusion, viz.,—that they are granitic mountains, now only overlaid with schists, having quite recently been released from their schistose covering. The true gneiss ranges are characterized by their steep and precipitous slopes with slightly rounded outlines, but with a green tinge absent from the granite; on the other hand the schists give rise to long slopes following the dip of the beds, whose smooth and polished surfaces glisten in the sunshine.

Wadi Sai'amin. — The upper part of Wadi Sai'amin is a very narrow ravine, whose existence would be difficult to explain without introducing tectonic changes. Here it is bordered by high vertical cliffs, which hide the peaks towering behind them.

Gebel Khalla. — One of these, Gebel Um Aleg or Khalla, was ascended and consisted on its lower slopes of a series of jagged ridges alternating with gullies filled with boulders, the former being due to the presence of dykes of syenite-felsite, etc. It had a curious effect, after wandering up precipice-lined water-courses and over boulder-strewn slopes, to suddenly emerge on the summit of a gently undulating

plateau, through which rise masses of the dark parent rock, this summit rock, which at the edge of the plateau gives rise to fine vertically-jointed precipices, being also felsitic in its nature, and forming the upper covering of the whole high mountain group to which Um Aleg belongs. A striking feature is the abundance of *hamr* (*Anabasis setigera*) at the highest points, looking almost snow-white by contrast with the deep brown-red colour of the rock itself. It was also remarkable to find a stone-circle in a depression of the plateau, this relic of human activity thus rivalling the circles of Haimar and Genaui in inaccessibility of position.

The Gebel Khalla range terminates in the peak of Gebel Sai'amin, which separates the ravine of that name from the wider valley of Wadi Lij, whose floor, formed of granite detritus, gives it a bright and cheerful appearance, while to the east the long ridge of Um Malaga is broken into the rounded bouldery summits so characteristic of granite hills, and is seamed by dark-blue dykes of dolerite. Vegetation is here abundant on the lower slopes, and in the upland hollows, the tall theman grass being most frequent near the base of the mountain where a few scattered seyal trees relieve the grim monotony of this otherwise desolate region. The descent from the ridge east of Um Malaga was made by Wadi Ethmiemat, where in a "fersh" or upland plateau, gravels were observed six metres thick, composed of granitic detritus and pieces of granite. These were distinctly, if roughly, stratified, and again lower down were found dipping in the same direction as the slope of the valley. Theman (*Peganum retusum*) and *kebad* (*Zollikoferia spinosa*) were both in great abundance, and water was present in five or six large pools lying in a small gorge cut out of the granite. This is evidently a favourite spot for ibex, and also the scene of many a tragedy, no less than tree pairs of horns showing that they had here fallen a prey to their active and wily enemy, the leopard. From the head of Lij is a bridle path communication with Wadi Um Athaga, while a similar one leads into Gnathel on the west, these being both suitable for riding camels.

To the west of Lij, Gebel Um Aleg rises in a frowning precipice, long talus of rock fragments descending from its lower slopes; while between it and the main valley are a series of pointed ridges due to quartz-felsite and microgranitic dykes. Wadis Lij, Sai'amin, Amlagh, and Adakkar, unite in the single sinuous gorge of Madsus, which is one of the most typical of the schistose hill-valleys. On both sides rise long, steep slopes of bedded micaceous schists glittering in the sun, and where they are traversed by dykes giving place to formidable precipices broken

through by deep gullies and torrent valleys. In the depths of the valley, only a few stunted bushes of *harra*, scattered in the stone-strewn ravine, maintain a precarious existence, while the dykes increasing eastwards add more and more to the complexity of the hill-form, and render caution in mountain ascending desirable.

Perhaps in our own case the impression was deepened by the atmospheric conditions, storm-clouds hanging heavily on the mountain summits, the whole culminating in a grand thunderstorm, where all the fury of the elements seemed to be let loose. The continual flash of lightning, the roll of the thunder, the roar of torrents, and the splash of the storm-rain on the bare rock combined to form a picture of chaotic grandeur such as is seldom witnessed, and remains indelibly fixed on the tablets of the memory. Long after the turmoil had ceased, a torrent rolling its turbid waters down Wadi Kyd alone broke the silence.

The upper part of Wadi Melhadge is, like Madsus, wild and inhospitable, bounded on all sides by bare hills, from whose flanks descend gullies strewn with enormous boulders. Conspicuous among these is Wadi Um Esherat, where the rock masses, rolled from the slopes above, recall similar confused boulder wastes in the Alpine regions. Hill-summits, only distinguishable by their form and tints, rise on either hand, to the east the sharp tooth of the Tower, further south the yellow-tinted Um Zeireh, connected to the red-dyked summit of Ras Achmar by a long crest.

To the east of the Tower hill, the granite forms hogsback ridges at a much lower level. Still further south, the ranges of the central watershed (Gebel Arabi) trend directly east and west, the dark schists composing them being entirely obscured by the abundance of the dykes which seam them on every hand. The sides of the mountains are steep and covered with talus of readily-rolling materials, while the crests are normally knife-edged ridges due to the dykes; so that the ascents of these comparatively low hills were often exhausting and difficult.

Throughout the whole region desolation reigns supreme, *Iphiona scabra* being the only plant in the wadis, and water alone being present after heavy rains. The most conspicuous of these east-west ranges is the Arabi or Ghrabi chain which rises into three main summits, the central one being most noticeable on account of its precipitous character. The western end of the range sloping towards the Gulf of Akaba is composed of granite, the change in the rock-structure being marked by a drop in the general level.

On the eastern side of Wadi Melhadge, the schistose country is much less broken by sharp ridges, the long shiny slopes forming a great

amphitheatre bending away from the valley, and rising to its highest levels in the summits of Madsus, Akhmara, Ethmemia, Um Sailem and Hamra.

After its junction with Wadi Melhadge, Wadi Kyd is deflected sharply southward, and shortly after is joined by two valleys from the east and west respectively. Both of these bear the name of Wadi Gebila, and are bounded by steep-sided schistose ranges, whose characters are similar to those already described. The eastern Gebila valley is of some importance, it being the first point south of Dahab by which a camel expedition can cross to the Gulf of Akaba. The pass presents no difficulties and the descent seaward is between slopes of light-tinted granite. In all respects the contrast was striking, behind us the dark hills, the stillness, the absence of life; in front the surging sea, teeming with tropical life, and stirred into continual motion by the fresh north-east breeze. In general the plain which lies between the hills and the gulf is a plateau which has been seamed by the winter torrents till it now descends in long tongues seaward, widening rapidly to the south, but to the north terminating abruptly where the rocky slopes of Arabi rise sheer from the waters. A prominent feature on the shore is the low white cliff or ridge of Ras Atantur, an old raised coral reef (20 metres high) on whose eastern flank is a storm-beach strewn with shells of *Tridacna*, *Conus*, *Natica*, etc.

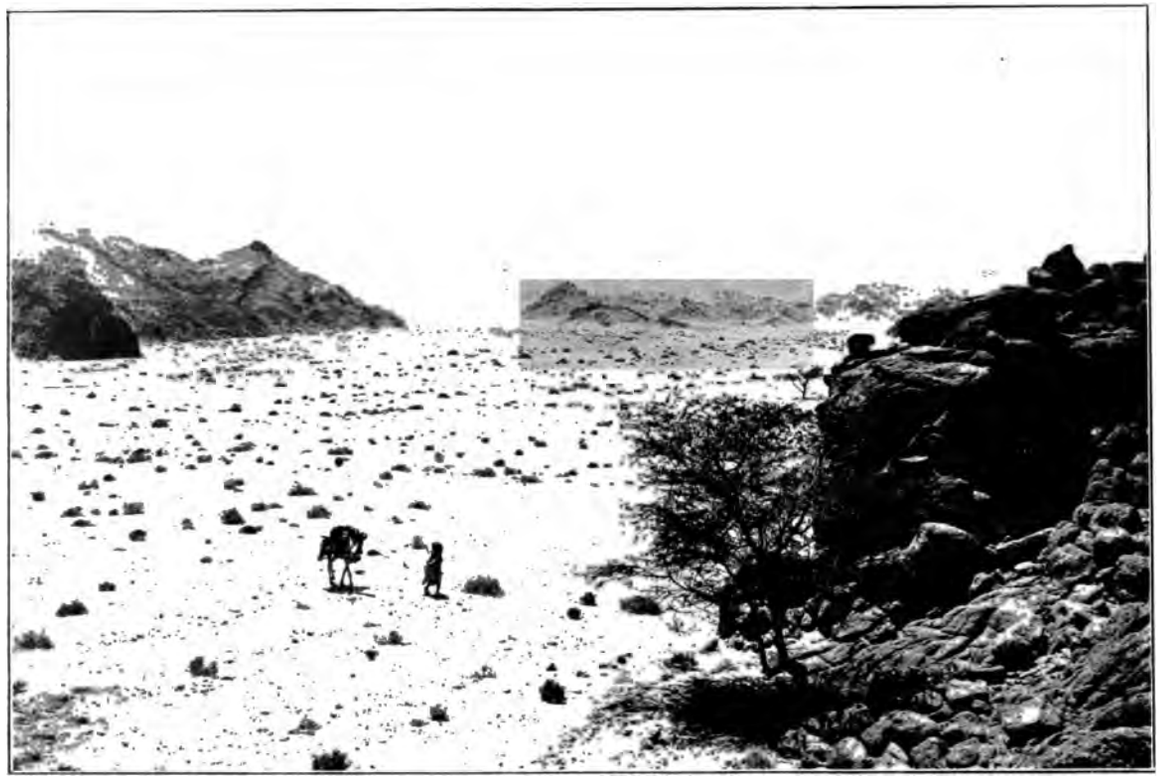
Returning now to the junction of Wadis Kyd and Gebila, the valley continues its course southward, the bounding hills becoming ever sterner, darker, and wilder, until suddenly at its junction with Wadi El Beda, the higher ranges cease abruptly, and only low foothills lie between it, the sea, and the western mountain ranges. At the mouth of the ravine a gravel terrace extends almost from side to side, and soon the dark schist scenery is replaced by the rounded, smooth, light-tinted, granite country which fills the space between Wadis Kyd, Um Adowi, and Merari. The change is also marked by the sudden increase in vegetation, *arta* (*Calligonum comosum*) bushes, in March green with fresh young shoots, following the watercourses, and attracting the gazelle from all quarters. Fifteen of these graceful animals were seen at one time, browsing peacefully and all unconscious of danger. Between the shrubs of *arta* the *'arra* (*Aerua javanica*) lifts its white-tufted woolly head, and the camels as they passed pressed down the aromatic *betheran* (*Artemisia judiaca*). Large bushes of *gurdi* (*Ochradenus baccatus*) carried minute yellow flowers on long thin stalks, and rounded clumps of prickly *somma* (probably *Cleome droserifolia*) filled the interspaces.

It may be owing to the proximity of this fertile spot that the neighbouring granite hills contain the largest hyæna colony in that part of the country. A well-marked track leads up wide, sandy valleys and across low hills of granite to the Darb el Dhuba, where large granite boulders lie in a confused mass. Underneath these the hyænas have burrowed, taking advantage of the shady spaces and hollows under and between the superincumbent rocks; in and around the openings are strewn the remains of many a raid, remains of camel-skulls and jaws, bones and horns of ibex and sheep, hair of ibex, and even a soda water bottle, the end broken off, but with cork intact, and pieces of iron. But though it was the full glare of midday, the animals themselves were nowhere to be seen, probably having scented danger long before we made our appearance. At this spot there are some ten dens. The Bedawi have a tradition that if an Egyptian fellah comes near a hyæna, the latter attacks and eats him, the fellah having a special scent. This may possibly have been of recent origin, and invented for the benefit of the Egyptian servant who accompanied our expedition.

On receiving Wadi Merari, Wadi Kyd bends sharply east, and leaving the granite ridge of Ras Berga on the south and some low foothills on the north, crosses the plain to the sea as a shallow water-course. The only noticeable features before it enters the plain are three well-marked flat terraces, two on the right flank of the valley, and one on the left at the corner where it enters the plain. Over the latter are scattered circular bushes of *arrak* (*Salvadora*) while dark-green groves of *shora* (*Avicennia*) fill some of the shallow sea-bays, prickly *Fagonias* being also common. On the other hand the valleys of the granitic regions of Um Berga are brightened by numerous seyal trees and bushes of *Zollikoferia*.

One important tributary system of Wadi Kyd remains to be considered, viz:—the one opening by Wadi Um Beda, which receives Wadis Tema, Genaui, and Yahamed. Wadi Tema itself is a valley of no great length forming for a short distance the boundary of the granite and schists, on the west being overlooked by a steep and many-crested granite range, while on the east rises Gebel Zegir, with softer outlines but sharp dip to the wadi. It was in this valley that some of the interesting "mictosites" subsequently described were best displayed.

Wadi Genaui enters from the west, itself receiving Wadi Gasab, which has a winding course from the Fersh El Gasab at the foot of Gebel Genaui, (see p. 67) and seen from above appears to be in the main a narrow ravine. The space between the three valleys is occupied by a confused mass of low hills extending to the plain, out of which



LOWER END OF WADI KYD, LOOKING WEST.

rise a few more conspicuous summits. Wadi Yahamed, descending from the central mountain chain is of more importance, and reversing the order usually followed in this memoir, will be traced from mouth to origin. Wadi Um Beda itself is still in the schists, but after passing into Wadi Yahamed the granite region is once more entered. This valley in its lower portion is broad and sandy, but suddenly narrows at the gates of Yahamed (Ergain) to a fine ravine, bounded on both sides by precipitous walls, while the central portion is studded with bushes and seyal trees to an unusual extent. This ravine opens out into a wide upland, bounded to the west by the rugged crests of the central range, and in other directions by spurs of considerable height. Only to the north is there a break in the hills, forming a camel-pass into Wadi Jendeli.

When camped one evening near the gates of Yahamed, a great cloud was seen to settle over the massif of Sabbagh, and when the pall lifted next morning, the mountain was covered with a sheet of glittering snow, no doubt to the great astonishment of the Qena Arabs, who though displaying no surprise acknowledged they had never seen snow before. The next day, camp was planted as high as possible in the boulder-valley of Sabbagh, the mountains round looking cold and grey, with snow lying thick in every crevice, and forcibly recalling the ranges to the east of the Furka pass.

On the 31st December, the party divided, Skill and one of the Arabs ascending by the dangerous-looking couloirs on the precipitous face, while the remainder, following the boulder-valley, approached the summit from the rear. The climb of a little over 1000 metres presented no special difficulties except such as were due to the circumstances of the moment, and the fact that the thistle-like *hashir* has a special preference for spots where hand-hold is most necessary, and its presence therefore specially objectionable. The Arabs suffered somewhat severely from frost-bite, whose effects lasted several days, and one here laid the foundations for an attack of nightblindness, which developed two months later, probably aided by the effect of the sun's rays constantly reflecting from rock surfaces. This awkward illness is very prevalent in Sinai, and in the case of the Arab above-mentioned began quite suddenly. The writer was descending from Gebel Madsus by a boulder gorge, and was a little ahead of the two Arab carriers, who had stopped to drink at an unexpected waterpool. Night was rapidly approaching, and as these ravines are very dangerous after sunset unless the moon be up, it was not advisable for the members of the party to lose touch of each other. On this occasion the light was fast

waning, when it became clear from the length of time that something must have happened, and re-ascending the gully, I found one of the Arabs was apparently stone-blind, and it was only with much difficulty that his companion had succeeded in bringing him out of the worst passages. Happily the sheikh, having grown anxious at our non-appearance, had ridden up the main valley on his camel, and was able to give the sufferer a lift to the camp, still some kilometres distant. It was a great relief next morning to find the true state of the case, but it was afterwards always necessary to send this Arab (who was one of the best climbers and carriers) on ahead, if there were any likelihood of being in the hills after night-fall.

The water-supply of the upper Yahamed valley is good, and consequently there is always here a small community of Arabs, who spreading their striped tents at the foot of the mountains find pasture for their camels, sheep, and goats, in the comparatively fertile uplands. South of the gates of Yahamed there is a break in the hills, an easy path which gives ready access to the third great drainage system of East Sinai, Wadi Um Adowi.

Wadi Um Adowi.—This wadi runs in an almost straight east-and-west line from the Adowi pass to Nebk. The upper part of the valley is a wide plain, above which rises the bold crest of Um Adowi, 1000 metres high, while at its feet sheep and goats graze tranquilly among the seyal trees.

The ascent of Um Adowi, which looks at first sight a serious undertaking, is in reality a mere climb, owing to the presence of the dolerite dykes which seam its sides. These trending at acute angles to the main ridge gradually ascend, now dipping into a boulder-gully, now rising on the sides of a precipitous slope, but always forming a natural road or series of steps slightly let in to the granite they traverse. Near the summit a broad boulder-gully crosses the dykes, and enables them to be abandoned; in it ausedj (*Nitraria*), kebad, zafara el gebel (*Iphiona*), ghassa (*Otostegia*) and getheeb are met with in great abundance, whereas in Sabbagh only myrrh (probably *Pyrethrum*) and hashir (*Echinops*) were observed. The highest point is a rounded knob of granite just large enough to hold the plane-table and observer, the precipice descending steeply from it on three sides.

In descending, Skill came across some fine pools of water, with maiden-hair fern (*Adiantum*) growing in abundance.

The upland valley at the foot of Um Adowi, and especially the gravel terraces which fringe its base, have been the scenes of strange

STONE CIRCLES AT FOOT OF ADOWI.

changes in past ages. On the terrace of Um Jeraif the stone-circle builder has been active, viewed from above it being apparently covered with a series of such circles, composed of an outer ring, and having a heap of stones in the centre. One of the larger was measured, its diameter being about 15 metres. The outer ring consisted of four tiers of stone blocks, 1·05 metres maximum height, the width of the wall being 1·8 metres, and the breadth of space between it and the central heap 3·6 metres. The diameter of the latter was 3·6 metres, and the western side of the wall 2·2 metres thick, it being somewhat lower than that on the east. The average diameter may be taken as 6 metres. Nothing remains to give a clue to the race who erected these strange constructions, and their memory had already long been hidden in the mists of antiquity, when a solitary monk built a solid stone rectangle at the foot of Um Adowi, its exit at so low a level that it is impossible to enter without stooping. He and his too have passed away, yet to-day the valley still exerts its attraction, the striped tent of the Arab being spread under the wind-sheltered slopes of the terraces, while women in long face-veils draw water from the mountain pools, and flocks of black goats crop the scanty herbage and young leaves of the seyal.

Long before this region had been reached, a white serrated ridge had been seen in the distance, rising ghost-like in the evening light. From the open plain Wadi Um Adowi narrowing, now skirted the foot of this hill, Gebel Barakat, a tumbled ruin of granite boulders seamed by the ever-present veins. On the north rise similar bare hills, the heights of Battagh and Somma, where great dykes stand out in long ridges from the crumbling granite slopes. The whole scene is a vivid record of the action of the denuding agents, here the long knife-edge of Barakat, its sides strewn with the giant boulders of its wreckage, behind it to the south an apparently confused mass of hills and valleys, out of which rise isolated domes, remnants of a granite mass that once was, while long red ridges trending in lines across the country owe their existence to the harder dykes which form their core. A little beyond Gebel Barakat, the great feeder of Letih enters Adowi from the south, the junction being overlooked from the east by the two sentinels of Themaih and Ajuaf, which rising from among relatively low hills, have an imposing aspect.

On the 9th of January, a cold clear morning (2°·0 C. at 6.30 a.m.) the hill of Hamra was ascended, and to the north-west rose the white dome of Zebir, clothed in a mantle of newly-fallen snow. From here fine terraces were seen in the valleys to the north-west and south-west,

while at its base Wadi Um Adowi was filled with low bushes of dafara (*Iphiona scabra*). The next station, Gebel Um Uwerid, involved a somewhat difficult scramble, owing to the very rounded nature of the granite summit, but commanded a fine view of Nebk and the Gulf of Akaba, the former being a beautiful palm-grove extending across the shallow waterway by which Um Adowi enters the gulf. The position of the palm-groves and wells is a feature worth noting, as it suggests that the water which has sunk in the gravels of the valleys is ponded back at its contact with the gulf. If this be so, a good water-supply may always be looked for at the contact of a large valley and the sea, unless the water has in its passage passed through rocks contaminated with salt. There seems no reason, for instance, why a good palm-grove should not be formed at the mouth of Wadi Kyd which shares with Um Adowi the distinction of being one of only two passages through the central watershed.

It has already been stated (p. 27) that Um Adowi receives the whole of its drainage from the south (with insignificant exceptions) the valley of Letih acting as the principal channel. This valley, which hitherto has been regarded as breaking through directly to the gulf is, as has been seen, deflected northward by low hills and a gravel ridge. Wadi Letih rises in a region of wild hills, among which Ethnarbi and Sahara take the first rank. Immediately at its head are two passes, that of Tehih being suitable for riding camels, while the one into Wadi Budr is only a sheep-track.

These mountains display all the characteristic features already so familiar in Sinai. A great dyke of dolerite, 40 metres broad, forms a natural road for a long distance along the summit of Ethnarbi, while others, crossing one another at sharp angles, present X-shaped figures in the precipitous slopes bounding the valley. Steep boulder-gullies descend from the surrounding hills, often terminating in "seils" (or dry waterfall beds) where now and then a rare pool of water fills some secluded and shaded granite basin. In the smooth stretches and among the boulders plant life grows in abundance, here bushes of *Zollikoferia* and scented *Artemisia*, there shrubs of *Nitraria*, *Otostegia* (with its white-lipped flowers), the dark masses of the aneb-ed-dib (*Solanum nigrum*), *Shouwia arabica* and the cruciferous *Harra*. Large terraces fill the interspaces between the hills, forming safe and suitable camping-grounds, while high in the centre of the ranges are many wide "fersh," where the ibex wander undisturbed, and are consequently present in somewhat large numbers.

The Arabs would not eat one of these animals shot here, because it had not had its throat cut immediately after death.

These upland valleys are also the home of many coneys, whose peculiar tracks are traceable in the soft gravels, and hares are also not entirely absent.

On Um Zeynig it was possible to test the magnetic effect of the spheroidal diabase dykes traversing the mountain side, the compass being deflected 10 degrees, while a thick dyke of dolerite was also found to have magnetic attraction.

Gebels Sahara and Ethnarbi command fine views of the whole southern stretch of Sinai, their western faces descending steeply to the plain of El Qa'a which, except for some low dyke foothills near the central range, extends unbroken to the deep blue waters of the Red Sea, beyond whose western shore rise the distant purple hills of the African wilderness. It was curious at times to watch great ocean liners passing to and fro, the sense of isolation being deepened by this apparent proximity to one of the greatest of ocean waterways.

Gebel Sahara commands a fine view of the complex scene in Eastern Sinai, the importance of the dykes which of huge size seam the mountain itself being very marked. The long ridge of Ethnarbi is seen to be formed by a red dyke, Barakat is crossed by four bands, two blue (dolerite) and two red (felsite), while Somma and Battach are lined with similar bands, whose normal direction of trend is to the north-east.

The sudden character of the rainstorms was well illustrated on February 11th. It had been proposed to ascend Gebel Hamra, but on the way the plan was changed, and Mobera, a commanding hill on the northern side of the valley selected as the station. The morning was clear and still, but soon after reaching the summit, clouds collected on the opposite slope of Hamra, the storm bursting over the latter at noon with terrific violence. In a few moments the whole mountain-side was foaming with innumerable cascades while the rocks rolling down the boulder-valleys descended with the roar of an avalanche. The front of the storm passed some 300 yards from our station, yet beyond some hail, a few showers, and heavy clouding, its effects were unfelt, and the day closed with a beautifully clear, still evening.

A cascade descending from the hill and forming a small stream was quickly swallowed up in the gravel of the valley, and masses of micaceous sand bound together where the torrents had passed were the only evidences of the storm yet remaining. A notable feature in the valleys are the streaks of black sand, which from their form and non-magnetic properties are in the main crystals of hornblende. A particularly fine seyal tree is also one of the features of the upper portion of Wadi Letih and formed a useful valley station.

The mountain portion of Wadi Letih terminates at the Gates of Letih (Ergayn Letih) where it issues as a broad valley (comparatively rich in vegetation) into one of the most characteristic of the Sinai dyke regions. To the south Gebel Haimar still extends its frowning buttresses for some distance, of which the two low granite hills of Khanashir and Mabledge might be regarded as advanced foothills were they geologically similar. Between them and Gebel Barakat is low granite country of peculiar character, the granite having undergone remarkable weathering into domes and pillars (see plate XI) or broad-backed rounded hills. Still more striking from the topographical point of view are the long ridges produced by the north-east trending dykes, these rising as low splintery crests, separated by shallow sandy valleys. Plant life is comparatively abundant in this region (see p. 96). The northward deflection of Wadi Letih by a gravel ridge has already been mentioned (see p. 27) and soon after it enters Wadi Um Adowi as a broad valley rich in *Artemisia* and dry *Zilla*. The valleys of the granite region on the west of Letih either fall into this valley, or when draining north-eastward, into Wadi Mandar, which skirting the southern foot of Barakat joins Letih near its junction with Um Adowi. To the east, the scene is wilder and more desolate; the twin peaks of Themain and Ajuaf rising stern and precipitous above the bare gravelly valley of Na'aj, where bushes of blue-green *Iphiona* and dry *Zilla* alone relieve its desolation. As stations these hills are splendid, commanding as they do the whole of the low country north, south, east to the Gulf of Akaba, and west, but otherwise remain in the memory only as a wild scene of bare rock and deep ravine.

Wadi Aad.—Of the remaining valleys of Southern Sinai, Wadi Aad is undoubtedly the most interesting and important. Commencing as an upland plain, it is dominated on the west by three important summits—Aad el Gharbi, Aad, and Haimar, the first two members of the central range, while the latter is one of its most important spurs. A low pass at the head of the valley separates Aad el Gharbi from the lower hills of Madsus and Awaja to the east, there being also a noticeable contrast in the form and tint of the hills on the two sides of Wadi Aad. The dark hill-ranges to the east are mainly hornblende granite, while a biotite-granite traversed by red felsite and dark dolerite dykes produces the characteristic rounded outlines of Aad el Gharbi. The wadis descending from Aad el Gharbi are also steeper than on the Madsus side, this also being the only spot in Sinai where we obtained the pretty little asphodel, (*Asphodelus tenuifolius*, Cav.)

GRANITE DENUDATION IN WADI LETIH.

previously found by the writer in Wadi Atilmi (Eastern Desert). The dykes of red felsite play an important part on the summit of Aad el Gharbi, giving rise to precipitous ridges forming a cock's-comb crest.

The plain of Wadi Aad is a favourite camping place with the Arabs, owing to the presence of a constant water supply in Wadi Moyyat el Aad. This narrow glen terminates in a fine ravine, where the boulders have been piled on one another in wild confusion, while in hollows between them are deep green pools of limpid and pure water. No ray of the sun penetrates its gloomy recesses, and the steep sides prevent the approach of ibex, leopard, and gazelle. Beyond, the valley opens out into smooth sandy expanses, where runnels of black sand line the grooves seamed in the soil by the storm-waters, and long mountain slopes rise on either hand, those to the west culminating in the peak of Gebel Aad. Looking from its summit northward, we see below us the thin boulder-stream of Wadi Mazea, and beyond the precipice wall of Gebel Haimar, while westward extends a long, thin crest, the watershed line connecting Aad with Gebel Sahara.

Gebel Haimar, rising grandly from the valley for over 1000 metres, projects forward from the main range, and is the highest point of a confused mountain system. A frontal attack would probably be attended with difficulty and even danger, but by ascending the flanking hills and crossing the ravine which descends its southern border, the highest crest can be approached from the rear, and can be crossed easily with the use of ordinary caution. The sense of bareness is also relieved by the presence of many bushes of *Zollikoferia spinosa* and *Anabasis setifera* on the mountain slopes, and it was remarkable to find a stone-circle on its steep sides. From its bend eastward Wadi Aad descends rapidly. On leaving the hills, it enters the plain as a broad depression bordered by gravel ridges and broad plateaux, from which rise isolated granitic hills and knolls. The most conspicuous of these is Gebel Dajilat, a typical low range of rounded granite slopes, often more awkward to climb than many of the more ambitious summits. In addition to this hill mass there are various isolated dyke ridges, which rise abruptly from the gravel plateau. Of these the most conspicuous are the Ras el Nimr and Ras el Hassainat. Circular bushes of sommu (*Cleome*) are abundant in this portion of Wadi Aad, associated with dafara (*Iphiona scabra*). Crossing the plain as a broad expanse, Wadi Aad becomes restricted between low cliffs as it enters the coral-reef region, and terminates in the delightfully secluded little bay of Aad, whose sandy shores are strewn with the rich shell treasures of the tropical sea.

Of secondary importance is the Awaja-Hedemia drainage system, consisting of bare desolate stony valleys taking their rise in low but steep hills, seen from the summit of Gebel Haimar to be a series of wedge-like ridges, running out into the valley with sharp points (due to dykes), and attaining their maximum heights in Gebels Um Markha, Awaja, Enumiah, and Fersh el Aad. In the upland portion are a few scattered seyal trees; sommu in low bushes of regular convex outline, and of rich yellow-green colour, and dafara, are the only vegetation, and here and there a waterpool was met with in out-of-the-way ravines.

The northern Wadi Awaja breaks through the hill barrier and grooving the granite plateau terminates in Sherm Bay. Sherm itself is of importance as having four wells, probably of ancient construction, but at the time of our visit the supply of water was very scarce, and it would not do to rely too implicitly on its presence at this spot. It is probable that the terror of the Arab on the opposite coast keeps this place absolutely deserted.

Sherm from whatever side it is approached is a striking spot owing to the strange colouring of the cliffs which surround it, those on the south being velvety-black above with deep tints of red in the lower half, while on the north the dead, white coral reef overlies bright-tinted sands. These combined with the blue waters of the inner bay form an effective combination, a picture not readily forgotten. Here morning, noon and night, with rare intervals, the breeze sweeps down from the north-east, becoming decidedly unpleasant when accompanied by rain, as was the case during our stay.

Sherm harbour is a well-known place of anchorage, one of the few along this reef-bound coast. The southern Wadi Awaja also breaks through the hill barrier, and for the major portion of its course is flanked on the south by a well-marked transverse ridge, Gebel Zafara; this hill, and the region generally, being well illustrated in one of the plates taken by the Pola Expedition. On the north is the low granite plateau, and the valley terminates seaward in the bay of Merza el Awaja, a sandy stretch which extends in a broad sweep from Sherm point to the projecting ledge at the foot of Zafara. When at Sherm the natives had informed us of the existence of a great inscription in this isolated spot, which naturally aroused our interest; our feelings may therefore be imagined when already some distance away we recognised two familiar Teutonic names painted large on a boulder, with a date underneath that marked too well its recent origin.

Wadis Hedemia and Madsus are the principal members to the south

of Gebel Zafara. These take their origin in the low hills bordering the upper portion of Wadi Aad and present no special features of interest, though Gebels Hedemia and Abuzag at the head of Wadi Hedemia have bold outlines and rugged crests.

When approaching the sea Wadi Hedemia, after passing some marked yellow hills about 200 metres high, is bordered by low cliffs of coral reef (a feature which is shared by all the minor valleys in this region), and terminates in a semi-circular bay very similar to that of Aad previously described. A noticeable feature in this region are the huge oysters which cover the summit of some of the low cliffs in Wadi Khorait, at the foot of Gebel Zafara.

South of Sherm the vegetation of the plains is very poor, being limited to galool (*a Zygophyllum*), dafara (*Iphiona scabra*) and dry bushes of markh (*Leptadenia pyrotechnica*) this being the only locality in Southern Sinai where this plant has been noted, while its presence here is of importance as a camel-food. Seyal trees are rare, except in the upper reaches of the valleys, while on the limestone reefs the dry woody Rose of Jericho (*Anastatica hierochunthina*) is everywhere present. Animal life is also very sparse in this region, though a short-bodied mantid is not uncommon, and a black stone-chat with white head was also noted.

South of Gebel Hedemia the hills rapidly lower, to the north being confused granite country, which further south is replaced by brightly tinted red and green crests, due to the extreme decomposition of dykes and rocks of allied nature.

Through this region Wadi Hashubi descends from the low watershed to the sea, being a wide and flat valley, in which arta (*Calligonum comosum*) and seyal were common. The arta at the time of our visit in January resembled dry wood, but even in that condition was readily eaten by the camels.

Two marked features distinguish this region from the remaining portions of Southern Sinai, blown sand covering the seaward slopes of the hills, in places almost to their very summits, while at the head of Ghazlani Bay such a sand-slope descends straight to the water's edge. On the other hand, most of the side-valleys in this region are filled with a flaggy sand-rock, forming terraces sometimes 10 metres thick, apparently connected with the drainage line. Where present these have precipitous sides towards the valleys, and in the wide gullies give rise to flat, smooth, level surfaces ending in abrupt vertical walls or steps, while the dykes rise through them in the form of low green and red ridges.

The peninsula of Sinai terminates in the long narrow promontory of Ras Mohammed, at its head being a limestone hill furrowed deeply by the wind-blown sand. The backbone of the peninsula is composed of a coral-reef limestone that has undergone much alteration, but which, expanding at the southern end, terminates in a bold cliff 100 metres high. On the northern side the beach of Ghazlani Bay (which is a wide inlet opposite the mouth of Hashubi) is covered with numbers of small Cerithia-like shells, associated with minute *Nerita* and bivalves, but as the rocky south end is approached it becomes more sandy. All round the eastern coast is a ledge of the lower reef, a shelf of coral which has the appearance of being suspended over the abyss, and beautifully blue-coloured fish disported themselves in the surf breaking over it. In places every slight depression in this reef is occupied by Ophiurids with blackish arms, here and there a brilliant red form (*Stylaster*) gives a pleasing dash of colour to the monotonous grey coral shelf, where small circular elevations rising from the general level curiously simulate miniature atoll structure. Further to the east in the small bays of the rocky coast, large crabs (probably *Grapsus*) are very numerous, apparently enjoying the surf which dashes over and around them. On the rocky islands which form the advance guard of the peninsula, the osprey finds a congenial home, while on the more open southern shore are hundreds of hermit-crabs, which have taken up their abode in every type of shell, *Murex tenuispina* included. The coral reef of the summit is exposed to the full fury of the gale, as is evidenced by its surface being furrowed and grooved in a north-east and south-west direction; in addition it has been in places rent asunder, the fissures trending normally east and west.

At the head of the peninsula is a small lake, which may be connected with the sea at high tide, the plain between it and the narrow channel which cuts off the southern point from the mainland being strewn with shells of the *Strombus* zone (see p. 139) this being also the case on the island itself. The separating channel is filled with shora trees (*Avicennia officinalis*) whose drooping deep green foliage contrasting with the dark-blue water forms a pleasing picture; on the island the osprey builds its nest, heron and egret also finding a resting-place in this forgotten spot, from whose bleak cliffs in years gone by the fleets of the then civilized world could be seen speeding their way over the blue waters of Akaba. In such wise ends the great central range and beyond this point descends an abyss fathom deep, while deep-blue waters stretch mile-wide on either hand, bordered only by the misty shores of Egypt and Arabia.

Region North of Wadi Nasb.

Differing materially from those previously described, to the north of Wadi Nasb is a region whose boundaries are shown on Plate XXII. At its second east-and-west bend this valley receives two important tributaries—Um Raiyig and Gura, the former being the continuation of the rift already described (see p. 27). The hills flanking Um Raiyig differ in structure, Gebel Hedjan el Gimal on the east being a dark-green crest with long talus-slopes to the valleys, while behind it the country consists of ridges of a striped schistose rock, the dip-slope in places being about 70 degrees south-east. On the western side, on the contrary, are the smooth rounded granite or gneissose slopes of Gebel el Heyala, whose summit is a broken plateau, from which rise isolated knolls of well-bedded Nubian sandstone, these being striped in red and yellow bands and often beautifully curved. At the highest point is an ancient circle, having an inner mass of stone piled up on the southern side, and a doorway formed of two low upright sandstone slabs on the south-west. Other circles of more elaborate construction are present at a lower level. Dragon-flies were met with in great abundance while descending this hill.

Wadi Um Raiyig terminates at its northern extremity at the foot of Gebel Um Raiyig in a broad expanse, which has a garden-like aspect owing to the comparative abundance of seyal trees and *Zollikoferia* bushes. Further south the valley is reduced to a narrow passage by a tongue of granite projecting from the eastern side. To the east rises the great dome of Rai'emshi, the country traversed to reach it being composed of granite seamed by many dykes of dolerite and syenite. The hill itself owes its conspicuous character to the capping of sand-grit which, 114 metres thick, overlies the granite, and a slight fault in the hill has given rise to two summits, from the highest of which the view extends over a wide granitic plateau overlaid by numerous hillocks of sandstone. There are also many stone-circles scattered over the country especially in Alfara, two being also observed on the watershed between Erdini and Udai.

Immediately on leaving Um Raiyig, a district is entered which is topographically very confused, owing to the faulting already described. Large sandy plains serve as excellent camping grounds, and from these rise vertical masses of white sand-rock, 100 metres high, weathering to a faint pink colour; the basis of the plains themselves is often a hard ferruginous sandstone. In a district of this arid character, it would not be surprising if water and vegetation were entirely absent;

this is, however, not the case, there being a well in Wadi Shegera, a somewhat slanting hole cut down into the tilted Cretaceous rocks, the presence of the water being due to gypseous marls, which are probably also the cause of its being slightly brackish. In this connection it may be noted that the Arabs obtain supplies of salt from near the surface in the plain of Barga. The vegetation, though specifically poor, is characteristic, consisting of abundant retem bushes and a small daisy-like composite *(Anthemis melampodina)*.

Wadi Safra (the yellow valley), a tributary of Wadi Sa'al, is the most important drainage line on the western side of the sheet, and continues almost to the foot of the Gunna escarpment, which towers above the low country as a gigantic wall. The boundaries of the lower part of the valley are gentle slopes of granite, on which further north rest bright red, purple and yellow sandstones weathering to a uniform yellow-brown tint. In addition there is a very ornamental "tigerskin" variety, consisting of alternating bands of purple and white sandstone.

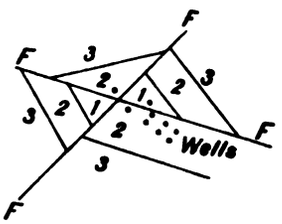
Above the purple and red beds rise outliers of white grit, forming bold precipitous buttresses often displaying a striking rectangular fretting on their flanks. The presence of a marked granite range almost under the slope of Gunna still further adds to the scenic complexity. The escarpment itself rises over 300 metres above the valley and extends in both directions as a solid wall, apparently unbroken as far as seen westward, but to the east shewing distinct evidence of the slow formation of isolated blocks through faulting and weathering. At its foot extend broad plains in which retem bushes are widely distributed, its summit being a broad rolling plateau, extending far to the north, probably to the borders of Wadi Zughera.

At the foot of one of the separated blocks (Gebel Hudera) is a ruined monastic building or *deir* 2·8 metres high, over 5 metres long and 2·8 metres broad, but slightly rounded at the corners. The whole is built of ferruginous limestone, 40·5 cm. thick, and pierced with windows 29·2 cm. high and 14·4 cm. broad, commanding a view of the hill. The door which faces eastward is as usual low, being just under 1 metre broad, 1·16 metre high inside, though stones heaped up outside have now reduced the height of the entry to 60 cm. The coping stone, over 2 metres in height, is not quite a metre above the door. Inside, the place was bare, except for some pieces of wood lying on the sandstone floor. From the summit of Gebel Rum a good view of the general relations of the escarpment were obtained, the latter

running back to the north, broken into by a series of huge bays, while to the east the fine cupola of El Ain rises in solitary majesty. To the north-east the country is a complex of dark sandstone resting upon granite, but a great maze of limestone is seen rising out of the midst of the range. The two hills of Abu Sowra and Um Rowa to the east are distinguished by the beauty of their colouring, being of delicate purple tints below and of a bright yellow colour above.

But the chief interest of this region centres round the beautiful little oasis of Ain El Hudera, which suddenly comes into view from the escarpment, a rich green gem set in the midst of stern and forbidding surroundings. Situated in a deep valley it is walled in on three sides by precipitous cliffs of sandstone though it is accessible from the south by a low pass ; while to the north extends the broad wadi of El Hudera belonging to the El Ain drainage system. The Ain (Arab, "spring") itself consists of two important springs, one of which has been tapped at several points ; some of these bores are deep, and clearly seen to be arranged along the line of a fault, which is continued in the small valley of Zarnuk Hudera. To the west of the main spring a second cutting has been made, the Arabs having in addition opened a groove, some 60 to 90 cm. deep, conducting the water to a small pond. The system of irrigation is primitive, a sluice being opened when needed, and water being in this way admitted along the shallow sandy canals. The chief objects of cultivation are date-palms, sidr *(Zizyphus spina-christi,)* yielding the nebk fruit, pomegranates (in full flower at the time of our visit), figs and barley or oats. The scene at this point is one of life and activity, blue rockdoves fly to and fro, while hundreds of hornets and dragon-flies bathe or hover over the water, and in the pond we noted for the only time a small worm-like animal with trumpet-shaped sucker, called "baluga" by the Arabs. In addition to the two main palm-groves, palms and rushes also grow in a small ravine close by, and it is curious to find numbers of *Melania tuberculata* in the sand, which in places lies thick round the palms. The walls of the tunnel through which the main spring is conducted are coated with salt, and are also the congenial home of large whip-like snakes.

The fault arrangement to which the water in all probability is due is shown in the accompanying figure, where 1, red granite ; 2, the ferruginous sandstone ; and 3, the white precipice-forming grits.



(Fig. 3).

Two passes lead over the watershed to Ain El Hudera, one a sheep-track winding down the steep face, while the path suitable for riding camels takes a more circuitous route to reach the valley. Baggage camels must of necessity go round by Um Rowa and Abu Sowra. Not far from the head of the sheep pass but lying on the main track to Akaba is an inconspicuous group of rocks (named by our Arabs Hejjaj), which seems to have received special attention at the hands of travellers, it being covered with inscriptions. Among these are Greek, Arabic, Cufic, and modern records, associated with spirited drawings of ibex, camels, and men riding camels in full movement. On leaving this point the road crosses the Nubian sandstone plateau, which is covered with a thin coating of sand and cindery blocks of black ferruginous sandstone, this in its turn being intersected by sandy gullies, in some of which grow kebad and dafara, the latter probably driven out of the main valleys by the retem plant. Seyal trees are here very rare.

Further to the east commence a series of step-terraces, the one at the head of Wadi Ejjebi, soon after it receives Wadi Um Muthela, being very steep. This drop is due to a fault which has brought the white or battlement grits below or level with the coloured ferruginous series. A second drop occurring at the end of Wadi Khothayat obliged the baggage camels to go back to the previous camp and descend by Abu Khothayat into Um Rowa, but riding camels can reach the same spot by a shorter route. The valley arrangement at this point has already been illustrated in a paper by the writer * where the succession of limestone ridges and plateaux of Nubian sandstone capping masses of granite is shown to be such as would result from folding and step-faulting.

In the valley of Ejjebi is a grove of alradeh or alrathe, a graceful tree 2 to 3 metres high, having a pointed leaf somewhat like rimth (*Haloxylon Schweinfurthi*) and a white stem similar to that of a birch. From this point it was seen that great quantities of sand had been blown through the gap at the head of Wadi Haduda from the Barga plain. Descending Wadi Um Raib the mountain-wall on the eastern side of the valley gradually increases in height; still further south similar granitic peaks close it in on the western side, and down the centre of the valley lie scattered patches of sandstone and limestone. Wadi Raib is at first very sandy, the sand having been drifted against the numerous alrathe trees by the wind. An ascent of the eastern mountain wall at several points shows it to agree in all its main

* "The Rift Valleys of Eastern Sinai," Intern. Geol. Congress, Paris, Aug. 1900, p. 10.

characteristics with the hill-country bounding the Gulf of Akaba south of Dahab. The highest points are those immediately overlooking the valley, which lies 300 metres deep below, steep wadis, full of boulders, descending to it between cliffs of red granite. On their summits are many pleasant plateaux with small valleys issuing from them bright with ja'adeh, theman, kebad, and ausedj, but as the latter descend seaward, they become grooves or forbidding ravines, formed by the raging torrents during times of storm, and terminating in secluded sandy bays, beyond which the surf of the gulf beats incessantly against the coral reef which lines the shores. Yet in these now silent valleys man has been active, for at their head between the dyke ridges is a number of well-built stone circles and semicircles, most of them with an opening, apparently as a rule facing south. Strange, too, it is to find one single isolated mass of sandstone, some 20 metres thick, forming the very summit of Gebel Kharaza, a silent and dying witness of the great covering which the hand of time has almost entirely removed ; far below the same beds extend southward in the valley, and on the westward heights opposite the sandstone can be seen creeping southward, first in mass over the igneous rock, then breaking into knobs and isolated outliers, and finally giving place to the dyke ridges seaming the granite hills.

To our Arab guide the recesses of these distant hills are no mystery ; he knows that far below is a practicable road from Dahab to Noweiba, along which baggage camels go slowly across the Um Isma pass into Um Raisen, thence the track leads to Wadis Rassasa and Amaiyid, where is water with palms, and arrak bushes near the sea. This is, in fact, the last point north of Dahab where arrak (*Salvadora persica*) is to be met with, asella (presumably *Suœda monœca*) taking its place between Noweiba and Akaba. Many minor tracks traverse these hills, these mainly leading to Wadis Amaiyid or Lebba. On the western side of Um Rai'b the conditions are very similar, most of the wadis (such as Abu Somra and Abu Habba,) commencing as smooth-bedded sandy valleys, dotted with seyal trees and kebad bushes, but at the edge of Wadi Raib giving rise to a series of precipitous ledges (Arab., "sidd") alternating with typical boulder-gully. These boulder-valleys are at times very dangerous, and on the last day of work one of the men slipped down one of these for over 10 metres, but happily escaped with only a severe shaking. These "sidds" were always a source of anxiety if the work were not terminated by nightfall, the most dangerous being usually those nearest the valley.

The season's work terminated at the mouth of Wadi Raib, and the subsequent march to Tor being made as rapidly as possible, there was but little opportunity for detailed observation. The return road first lay through the ravine of Wadi Nasb, and then entered the truly magnificent gorge of Wadi Gura, where huge precipices towered for hundreds of metres above the narrow and winding ravine. On entering Wadi Zagara and approaching Habshi, the schists again made their appearance, the country opening out in consequence, and having the depressing green colour and barren character of such regions. Near Senned the granite reappears in force, and the track winds among the low, rounded pink hills until it opens out into the great plain of Senned, at the time of our passage in May, filled with bushes of *ajerum* and the smaller *haremlan*, the latter said by the natives to be good for toothache. To the south of the plain extends the great ridge of Um Allowi, while to the west a low and easy path across the watershed leads into Wadi El Sheikh opposite the well-known tomb of Sheikh Saleh. From here a flying visit was paid to the Convent and Holy Mountain, a well-kept road leading to the summit of Gebel Musa, which as has often been remarked is entirely unsuitable as the centre of the grand events described in the Book of Exodus, deep beneath being but narrow clefts and barren unimposing valleys. The great spur of Safsafeh, on the other hand, commanding as it does the wide plain of Er Rahab and the Wadi El Deir, is a suitable spot for the promulgation of the Law, and this isolated region, hidden behind rocky barriers and possessing one of the most invigorating climates in the world, is fit indeed to change a horde of Oriental slaves into a nation of hardy warriors. There is undoubtedly a charm around this ancient crest, which Christian, Hebrew, and Moslem alike regard as one of the holiest centres of their religions. As we ascend, high plants of *Verbascum*, reminding us of the familiar mullein at home, blossom on the roadside, while the summit (in late May and early June) is clothed with myrrh (*Pyrethrum santalinoides*), which when crushed under foot exhales a powerful aromatic odour.

Here, side by side, are the two small buildings devoted respectively to Christian and Moslem, while on neighbouring heights rise crosses, marking the traditional site of some famous Biblical scene, annually visited by the Russian and Greek pilgrims who are personally conducted by the monks to the holy places. Far down in the valley below is the Convent-fortress, which since the days of Justinian has stood as the last relic of monastic influence, its dark-green cypress trees lending an unexpected beauty to the wild scene in which they find a home.

PLATE XII. (a)

SINAI CONVENT.

PLATE XII. (b)

GARDEN OF SINAI CONVENT.

Descending from the Convent by Wadi El Sheikh the road passes through the cleft of El Watiya, a narrow winding gap which forms one of the important points of connection between Sinai and the outer world. Immediately on passing the gorge the country opens out, many-dyked granite hills lying to the north, while in the valley itself is a grove of tamarisk trees bordered by remarkable light-coloured terraces. At the time of our visit these graceful trees were filled with a dark locust-like insect, a Cicada, and were exuding a very sweet transparent gum, appearing like drops of water, and known to the Arabs under the name of "man". It has been stated that the insect above-mentioned plays an important part in the production of the *man* but this point it was impossible to determine owing to lack of time, the locusts themselves being very difficult to discover, although the rustling in the trees showed them to be present in large numbers.

Descending Wadi Gharbi the well-marked gneissose district was entered, where coneys were busily engaged running underneath and between the boulders, while a spiny-tailed *Uromastix* sought shelter in the clefts of the rock. At eventide the scene crossing the low plateau at the head of Wadi Hebran was beautiful in the extreme, the serrated ridge of the mighty mass of Serbal showing slate-grey in the evening light, while beyond the deep valley the great dome of Madsus still glowed rose-red, then gradually faded into purple at approach of night. Wadi Hebran with its many palm-groves, its running streams, its rugged bounding-hills, is a beautiful spot, torn in winter by many a rushing torrent, as is seen by the present condition of the broad road which Abbas Pasha made when he lived in his Sinai palace, now standing forlorn and desolate. Passing from the hills through a narrow gap, the valley for a short distance extends seaward as a shallow groove, finally opening out into the vast plain of El Qa'a stretching westward to the sea. Owing to the stringency of quarantine regulations at Tor, the return to Suez involved a further six days' traverse of the desert, first across the sun-swept plain of El Qa'a, thence skirting the seashore across the plain of Markha, past the cape of Abu Zenima and the great black dyke of Tayiba. Thence bending desertward through the valley of that name past the palm and tamarisk groves of Useit and Gharandel, the "great and terrible wilderness' is entered, where the sand sweeps in blinding eddies along the camel-track, the low gypseous hills enhancing the desolation, while everything is distorted by ever-present mirage. After two days' traverse through this monotonous and

arid waste, welcome indeed is the sight of the palm-groves and seven springs of Moses' Wells, the desert outpost of Suez, where terminated our eight months' wanderings in this inhospitable but interesting wilderness.

CHAPTER IV.

BOTANICAL NOTES.

Sinai has been the scene of numerous botanical explorations, the following being the most important.* Ehrenberg and Hemprich visited Egypt, Arabia Petrœa, and Syria from 1820 to 1823, and brought back collections which were never described. Dr. Rüppel, who made a careful examination of Sinai between 1822 and 1826, also made a collection, which was recorded in his "Beiträge zur Flora Aegypten und Arabien." The plants brought by Bové in 1832 were determined by Decaisne, and published in the "Annales des Sciences Naturelles," under the title of Florula Sinaica.

In 1835 Schimper made a detailed examination of the Mount Sinai neighbourhood, and Boissier in 1846 also visited the same district, while in 1867 he summarized the whole of the previous observations in his monumental work, the "Flora Orientalis," which also forms the basis for a useful flora published by Post.

The botany of Western Sinai has during past years been the subject of detailed studies, the results having been brought together in Boissier's monumental work, and further summarized in Post's "Flora." A collection was also made by the Ordnance Survey which under Sir C. Wilson mapped this district, the plants having been named by Sir J. Hooker. A valuable collection has recently been made by Herr A. Kneucker, who in an expedition from Tor to Suez through the central mountain range between March 30and April 13, 1903, obtained 272 species of phanerogams, or more than half those recorded in our list, the results for the cryptogams were particularly valuable, of 20 species of Bryophyta no less than 14 being new to the peninsula. All the algæ in our list are also due to this expedition except the Diatomaceæ, which were more especially noted by the Ordnance

* See BOISSIER, "Flora Orientalis," Vol. I. p. XXI.

VIEW OF SINAI FROM GEBEL KATHERINA.

Survey, while the Ayun Musa forms were collected by Drake, Fraas, and Wilson, and those of Tor by Haig.

Where plants have been collected by members of the Geological Survey, these are marked respectively as Hume or Barron Coll., and the authority for the name in most cases is Dr. Schweinfurth, who kindly helped the author in this important respect; the Kneucker Coll. is next given precedence, as this botanist kept careful account of localities and mode of occurrence. He did not, however, obtain the Arabic names, and the authority for these is shown by the initials P.F. = Post's Flora, or O.S. (Ordnance Survey).

The authorities for Herr Kneucker's identifications are given in a paper entitled "Botanische Ausbeute einer Reise durch die Sinaihalbinsel" in Allgm. Botan. Zeitschrift n° 7–8, 1903. It is satisfactory to know that the same botanist is now undertaking an examination of the Eastern Sinai region, Herr Guyot at the same time collecting the insects, so that further valuable observations may shortly be expected.

In the Egyptian Geological Survey Report on the "Topography and Geology of the Eastern Desert of Egypt" a list of 50 plants was given, representing the most typical members of the desert flora between lats. 26° and 28° N. in that region. A similar collection, embracing 56 species, has been made by the writer in Eastern Sinai, the majority of these being, as in the former case, most kindly named by Dr. Schweinfurth. These identifications are not sufficient to enable the botanical position of Eastern Sinai to be determined in relation to the better known districts lying to the west of the Gulf of Suez, but by comparing the results in Schweinfurth's and Ascherson's well-known flora and the list given in this work, a good idea of its true relationship may be obtained.

Resemblance of Eastern Desert and Sinai Flora.

A glance at the appended list is sufficient to show that in their broad outlines the two regions have a close resemblance, two-thirds of the Sinai species also occurring in the eastern Egyptian desert, but an examination of details shows some interesting points of difference.* In the Eastern Desert flora are a number of species which are evidently of southern origin, and have obtained but little footing in Sinai. The most notable of these are the *Cocculus Laeaba*, which is an abundant climbing plant in the Sudan; *Morettia phileana*, one of the most widely

* The writer has not had the opportunity of revising this list in the light of the new material collected by Herr Kneucker, but it is not probable that the relations would be materially altered.

distributed crucifers in the valleys of the cataract district and in the larger wadis north of the Qena-Qosseir road, has rarely been noted in Sinai,* while the beautiful *Moringa arabica*, which seems specially suited to the secluded glens of this mountainous region, was totally absent on the eastern side, though Barron informs me that it occupies a definite zone in Wadis Hebran and Mear on the western. Other notable absentees are the *Acacia Ehrenbergiana*, one of the most widely-spread of eastern desert and Sudan shrubs, and in Eastern Sinai the Asclepiad *Daemia tomentosa*, another widely distributed Egyptian desert plant, though the latter has been recorded in various Sinai lists as present on the western side.

Character of Flora at Southern End.

In this connection special attention may be called to the extreme southern end of the peninsula, where a few of the most important members of the eastern desert flora have succeeded in obtaining a precarious footing. The *Leptadenia pyrotechnica*, which forms one of the most conspicuous bushes in mountain valleys north of Qosseir, only occurs in a stunted form in the neighbourhood of Sherm, and northward along the line of the Dead Sea rift, while the *Avicennia officinalis*, the large willow-like mangrove which fills many of the bays north of Qosseir, has only succeeded in establishing itself in the small channel between the island and the mainland at the south end of Ras Mohammed and along the shore near Nebk.

Characteristic Plants.

Undoubtedly the most widely distributed of all the South-east Sinai plants is the low prickly composite *Iphiona scabra*, which when eaten too freely by camels or ibex forms a compact fibrous ball in their intestines, eventually by its growth causing the death of the animal affected. Other characteristic plants are *Otostegia microphylla*, *Gymnocarpus decander*, and *Pyrethrum santalinoides*. On the other hand many eastern desert plants are quite as much, if not more, widely distributed in Sinai, among these being *Artemisia judiaca*, *Salsola fœtida*, *Calligonum comosum*, *Capparis spinosa*, *Ochradenus baccatus*, *Zollikoferia spinosa* and the seyal (*Acacia seyal*). *Salvadora persica* extends along the coast of the Gulf of Akaba as far as Noweiba, where it is replaced by

* In Qa'a plain, by Kneucker.

the asal, presumably *Suœda monœca*. The rarest of all the plants in this district is the single representative of the Umbelliferæ, *Zozimia absinthifolia*, found near the head of Wadi Humr, and previously recorded from Gebel Um Khasheyba east-north-east of Suez by Figari, on the high plateaux at the origin of Wadi Jendeli, and between the heads of Wadi Warag and the upper Wadi Rischrasch. *Malva rotundifolia* was only noted as a small patch at the head of Wadi Letih, but may have been cultivated by one of the Arabs.

Distribution of Plants.

There are some noticeable differences in the distribution of the various species according to height and rock-structure. In the great plain (Qa'a Plain) on the western side of Sinai near the sea, only a few Zygophyllaceæ, mainly *Zygophyllum album*,* seem able to survive the inhospitable conditions, *Aristida caloptila*, *A. plumosa* and *Danthonia Forskalei* taking its place in the central portion, and *Artemisia judaica* becoming very abundant as the mountains are approached. Immediately the mountain-valleys are entered, the vegetation becomes relatively abundant and varied—palms, reeds, seyal, tamarisk and jungle of bulrush and reed beautifying many an otherwise wild and rugged mountain glen. The familiar *Zilla myagroides*, *Zollikoferia spinosa*, and *Artemisia judaica* line the more prominent water-channels, while bushes of *Capparis spinosa*, with bright green leaf and large yellow flowers, occupy many a precarious foothold in the clefts and crannies of secluded ravines. After crossing the central chain into Wadi Nasb *Salsola fœtida* was noted as being one of the most prominent of the valley shrubs, and large bushes of *Gomphocarpus fruticosus* filled the air with their scent in the upper portion of Um Gerat. On the eastern side scattered seyal are grouped at the heads of the small valleys draining the steep-sloped central chain, while in their lower portion as they widen seaward, prickly shrubs of *Iphiona scabra* and *Cleome droserifolia* diminish the bareness of an otherwise desolate region.

A few lists may here be given showing the typical distributions in some of the principal valleys:

Wadi Isla: Palms, reeds, phragmites, *Artemisia*, maidenhair fern (*Adiantum*) in small streams.

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* Kneucker states the desert plains are characterized by succulent *Zygophylla*, *Chenopodiaceæ*, *Aristida*, *Danthonia Forskalei*, *Brocchia cinerea*, *Artemisia cinerea*, etc. See also A. Kneucker (Allg. Botan. Zeitschrift N° 7-8, 1903.

Wadi Nasb: *Salsola*, tamarisk, palm, reed, bulrush, *Capparis*, *Calotropis*, *Artemisia*.

Crossing the transverse range there is a marked change:

Wadi Rahab: *Crotalaria*, *Iphiona*, *Aerua*, *Zilla*, *Zollikoferia* and *Salsola*.

At head of Wadi Kyd: Many *Capparis*, gazuch (smelling like a carrot), *Retem*, *Zilla*, *Zollikoferia*, *Artemisia*, *Lycium arabicum*.

In lower part of Kyd: *Calligonum*, *Diplotaxis*, *Artemisia*, *Zilla*, *Cleome* and *Ochradenus*.

In the upper reaches of Wadi Letih there was a very varied vegetation, especially in the boulder-valleys entering it from the central hills. Among these the Labiate genera *Otostegia* and *Lavendula* are conspicuous.

In addition the following were noted: *Robbairea*, *Trigonella*, *Zollikoferia*, *Artemisia*, *Diplotaxis*, *Achillea fragrantissima*, *Anchusa*, *Capparis*, *Lycium*, *Solanum retroflexum*, *Picris* sp. and *Malva rotundifolia*. Numerous other flowers are present, having the following Arabic names: raffiya, glayitterai (a plant with soft leaves and a yellow flower), lassag (? *Forskalia*), daha and hotham*. The flora of this region has been described in greater detail owing to its being somewhat off the beaten track.

Mountain Flora.

While the plants of Sinai are undoubtedly most abundant in the deep valleys and boulder-strewn ravines, there is a very definite flora which flourishes more readily on the bare mountain slopes or even on the wind-swept summits. Two of the most typical members are the aromatic composite *Pyrethrum santalinoides*, which at the time of our ascent of Gebel Musa covered the slopes immediately beneath the summit, every step crushing these odoriferous plants, and the air being heavy with their scent. Another plant of still wider distribution on the eastern side of Sinai is *Anabasis setifera*, which has been noted on the summit of most of the important mountains in the peninsula, (especially abundant on the summits of Fersh Sheikh el Arab, Beidha, Asafia and Aleg).

On Sabbagh, on the contrary, two other plants took their place, one a

* Special attention may also be called to a small tree from two to three metres high, which has a jointed leaf resembling that of *Haloxylon Schweinfurthi* and a white stem similar to that of a birch. These are known to the Arabs as "alrada" or "alratha" and occur in abundance at the head of Wadi Raib.

small *Artemisia*-like fragrant composite, the shia el gebel (Arab.), and the other a spiny thistle, probably an *Echinops*, which has a disagreeable habit of growing on the rock-ledges by which the ascent has frequently to be made. On Um Adowi the heads of the valleys immediately below the summit are filled with *Lycium arabicum*, *Zollikoferia spinosa*, a small *Iphiona*, probably not *scabra*, the dafara el gebel (Arab.), *Otostegia microphylla*, and a plant known as gethib. On Haimar *Zollikoferia spinosa* and *Anabasis setifera* ranged almost to the very summit, while jeradeh* (? *Gymnocarpus*) filled the heads of the high valleys in Gebel Gnai.

Streaming of Flora.

On the other hand, the Akaba gulf plain flora is not extensive, being limited in the main to palms (as at Dahab and Nebk), *Salvadora persica* bushes, reeds of various kinds, *Iphiona scabra* and pulpy-leaved *Zygophyllum*. An interesting feature in Sinai is the *streaming* of the flora of one region into another along the line of the rift-valleys. When Dahab was reached it was noticed that *Haloxylon Schweinfurthi* made its appearance for the first time, and on tracing the plant-life of Wadi Nasb it was found that this plant ceased east of its junction with Wadi Sa'al coming from the north. A subsequent traverse showed that *Haloxylon Schweinfurthi* was abundant in the latter valley, associated with *Retem retama*, which similarly had been able to extend southward along this deep groove in the granite hills.

Retem is in fact, with *Haloxylon Schweinfurthi* and *Anthemis melampodina*, the characteristic plant of the northern portion of mountainous Sinai, being the most conspicuous feature in the plains and larger valleys lying between the Cretaceous escarpment and Wadi Nasb. The portions of Sinai studied may be roughly divided into several zones. 1. The *Retem-Haloxylon Schweinfurthi* zone, embracing the high plateau country above mentioned. 2. The *Iphiona scabra* zone, including the triangle enclosed between the triple watersheds, and having an *Aerua* sub-zone, the arid schistose region south of Dahab where the *Aerua javanica* alone appears to flourish. 3. *Anabasis setifera* and *Pyrethrum santalinoides* zone, this including the mountain summits and slopes. 4. The *Zygophyllum album* zone of the Great Plain. 5. The *Salvadora persica* zone of the Akaba coast.

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* This plant requires closer examination.

The following notes deal with the distribution of the natural orders and the species composing them:

Distribution of Natural Orders.

I. The *Cruciferæ* are represented by five species in the collection: 1. *Mathiola arabica* according to Hooker; 2. *Shouwia arabica;* 3. *Diplotaxis harra* (Forsk.) (see Boissier I. 388) is a small plant bearing a yellow cruciferous flower with four long and two short yellow stamens and one long pistil with yellow point. It was especially noted in Wadi Letih and its tributary valleys. 4. *Zilla myagroides*; and 5. The rose of Jericho (*Anastatica hierochuntica*), the well-known dry-looking ligneous plant which expands its woody-looking flower when placed in water, and one of the commonest plants on the coral terraces bordering the Gulf of Akaba. The other species are all of frequent occurrence in the mountains. The *Zilla myagroides* is here, as in the eastern desert, one of the most characteristic of the desert plants, occurring in bushes in the valleys, and easily recognised by its prickly branching and white to purple cruciferous flowers. It extends throughout the peninsula to the shores of the Gulf of Akaba, giving its name to Wadi Um Bsilla, one of the branches of Wadi Letih.

II. *Capparidaceæ*. The genus *Capparis* belonging to this order is of wide distribution, being abundant in the high valleys of the granitic region, and generally known to the Arabs of both Egypt and Sinai under the name of lassaf, while its peppery fruit is much sought after by the desert dwellers. The principal species is *Capparis spinosa* (Boiss I. 420). In Sinai it occurs in all the main valleys, and is also common on the slopes of Gebel Tellat Unsair, and in the higher valleys of the Ferani range.

Cleome is another representative of the Capparidaceæ in Sinai, the most striking species being *C. droserifolia*, Del. (see Boiss. I. 415), which has a drosera-like leaf covered with small prickles, and usually occurs in small semi-circular bushes having a disagreeable smell. It is probable that the "sommu" of Southern Sinai is this species. *Cleome brachycarpa* and *C. chrysantha* appear to be invaders from the south.

III. *Resedaceæ*. This natural order is represented by the abundantly distributed bushy *Ochradenus baccatus* Del. (see Boiss. I. 422.), which appears to be limited to the main mountain valleys in Sinai, being very noticeable in Wadi Hammam (Sa'al), Nasb and Kyd. The small

mignonette *Reseda pruinosa*, has been recorded by Sir J. Hooker from the collections made by the Ordnance Survey in Sinai. *Reseda stenastachya*, Boiss., appears to be a local form.

IV. *Silenaceæ.* Among the collection made at the head of Nasb there was a small plant with very hairy leaves and a small yellow flower, *Silene villosa*, Forsk. (see Boiss. I. 592). This plant was also found at the head of Wadi Letih. Of even more frequent occurrence on the mountain slopes at the head of Wadi Humr is *Gypsophila Rokejeka.* This order is especially rich in local species.

V. *Paronychiaceæ.*—This order is represented by the small *Robbairea prostrata*, and possibly by the important mountain plant *jeradeh*, provisionally referred to *Gymnocarpus decander*, abundant on Um Zeinig and Gnai.

VI. *Tamariscaceæ.*—The tamarisks are among the most characteristic members of the Sinai region, groves of these trees filling the broad valley of El Sheikh near the head of Solaf, while they also lend beauty to the deep ravines of Eastern Sinai, being especially abundant in the gorges of Wadi Nasb. The commonest species is perhaps *Tamarix mannifera*, Ehrenb. (see Boiss. I. 975) from which exudes the sweet gum known to the Arabs as *man.* In May the Solaf groves were infested with a form of *Cicada*, which crowded every branch and had probably been attracted by the manna. The general Arabic name is tarfa and owing to these trees being largely used by the natives for fire-wood many fine tamarisks are annually destroyed, there being no effort made to replace the waste.

VII. *Molluginaceæ.*—A small *Glinus* is the only member of this order recorded, being known to the Arabs as lepetha.

VIII. *Malvaceæ.*—The only example of this order, the kobbeyza *Malva rotundifolia*, has already been referred to.

IX. *Geraniaceæ.*—At the head of Wadi Aad a small plant was obtained to which the Arabs gave the name of dahemi, and as it showed the characteristic fruit of the stork-bills, was noted as one of the Geraniaceæ. The species is possibly *Erodium bryoniæfolium*, Boiss., described by Post under the name of dehamin.

X. *Zygophyllaceæ.*—This order is the most widely represented in the limestone deserts, where everything seems to be against the growth of vegetation. Various species are of common occurrence in Sinai, the principal forms belonging to *Zygophyllum* and *Fagonia*, most frequently met with in the plain of El Qa'a and that bordering the Gulf of Akaba. The ghargad (*Nitraria tridentata* or *retusa*) grows abundantly in Wadi Sa'al and on the shores of the Gulf of Akaba, where its sweet berries attract hundreds of hermit-crabs.

XVI. *Rhamnaceæ.*—This order is represented by the sidri tree (*Zizyphus spina-christi*), whose small crab-apple-like fruit, known as nebk, is a favourite food among the Arabs. It is only present in some of the more favoured valleys, and especially in the recesses of Wadi Kyd.

XVII. *Moringaceæ.*—The beautiful *Moringa*, though present on the western side of Sinai, (apparently with a definite height-zone according to Barron), does not appear to have crossed the watershed, and is therefore not included as a member of the Eastern Sinai flora.

XVIII. *Leguminosæ.*—As might be expected, this order is of great importance in Sinai, including some widely-spread members. Among these the most conspicuous is the *Retama rœtam*, Forsk., which is the most characteristic bush in the north of Sinai, though its range also extends southwards along the rift valleys. Species of *Astragalus* are also of common occurrence, and the senna (*Cassia obovata*) is widely distributed in the lower reaches of Wadi Nasb, where its familiar yellow flower and characteristic fruit cannot fail to be noted.

But most important of all are the *Acacias*, which under the name of seyal beautify the upper reaches of the valleys, supply fuel and food-supply for the camels, while the native dweller himself does not despise their leguminous pods. Unfortunately the formidable spines of these trees, which are often strewn round their bases, detract from their value as shade-givers, while the gum which exudes from their stems attracts innumerable insects and especially ants. This is reputed to be the "shittim" of the Biblical record. The poisonous *Lotus arabicus* is also a member of the local flora, and on the western side are graceful little *Trigonellas* and *Lotononis*.

Members of the Rosaceæ and Crassulaceæ were never met with during our expedition, and the Cucurbitaceæ were also but feebly represented, *Citrullus colocynthis*, L., so common a member of the eastern desert

flora, being but rarely observed. The same statement applies to the Umbelliferæ, (*Zozimia absinthifolia*, Vent.) having been only once noted at the base of Gebel Asafia. It is possible that a plant smelling like a carrot, and known as Qasuch according to Post, may be the *Deverra triradiata*, Hochst., belonging to this order. On the western side, Um Shomer receives its name from the abundance of *Ferula sinaica*, Boiss., Arabic name = Shomer.

XXVI. *Compositæ*.—As might be expected, this great order includes some of the most striking members of the Sinaitic flora, and one plant, *Iphiona scabra*, D.C., is practically characteristic of South-east Sinai. Reference has already been made to the dangers incurred by eating this plant, its fibres forming a solid ball in the stomach, and eventually leading to the death of the animal affected. In the northern plain *Anthemis melampodina*, Del., takes its place, growing in isolated plants rather than in low bushes, and has a strong resemblance in form to a daisy. Here belong a large group of aromatic plants, including the fragrant *Pyrethrum santalinoides*, D.C., which covered the summit of Sinai in June and is a characteristic mountain flower, while in the valleys the yellow-flowered *Artemisias* are in even greater abundance. The thistle *'Echinops glaberrimus*, D.C., is at times unpleasantly conspicuous, while a mustard *(Senecio flavus* Schz.*)*, with modest yellow flower, hides itself among the nooks and crannies in the boulder valleys.

Constant reference has been made to *Zollikoferia spinosa*, Forsk., whose spinose bushes are distributed alike on mountain-side and in deep valley.

XXVIII. *Salvadoraceæ*.—*Salvadora persica*, Garcin. is the characteristic shore plant of the Gulf of Akaba, its straggling tangled stem extending equally in all directions, so that the bush produced is low, widely spread, and strikingly circular in form. According to the Arabs, it is not present to the north beyond Noweiba.

XXIX. *Asclepiadeæ*.—The Asclepiads are similar to those already recorded from the Eastern desert, the highly-scented hardjel (*Gomphocarpus sinaicus*, Boiss.) with bunches of white flowers and pear-shaped fruit being present in many of the mountain valleys. The local distribution of *Calotropis procera*, Willd.* is peculiar, it being

* This plant is really a southern form, being of wide extension in the Sudan, where it grows freely as a weed on land which has gone out of cultivation. The milky sap of its thick leaves has a highly poisonous character, when applied to the eyes, producing blindness.

relatively abundant in the higher reaches of Wadi Gnai while elsewhere it is seldom met with. *Leptadenia pyrotechnica*, Forsk., is also limited to the southern extremity of the peninsula. The *glayitterai*, of which no specimen was preserved, is possibly a *Dœmia*, but the familiar *Dœmia tomentosa* was not noted by the writer, though observed by the Ordnance Survey.

XXX. *Borragineæ*.—Plants of this order are fairly abundant, the hamima, of the Ordnance Survey, being probably our ekhmim (*Trichodesma africanum*, L.) from the northern sandy plains, while *Anchusa Milleri*, Willd. is ubiquitous.

XXXI. *Convolvulaceæ*.—This order is rare in Eastern Sinai, only one example of *Convolvulus hystrix*, Vahl., being obtained at the foot of Gebel Gnai where it forms large bushes. In Western Sinai, and especially in the northern portions, it appears to be more extensively represented.

XXXII. *Solanaceæ*.—This order includes several poisonous members, *Solanum retroflexum* strikingly resembling the woody nightshade of England and northern Europe. One large bush, *Lycium arabicum*, Schw., is also of frequent occurrence as in Wadi Sa'al, but the most common of all are the sekkerans (species of *Hyoscyamus*) whose bright-coloured flowers rising on thick stalks among foxglove-like leaves at once arrest attention wherever present.

XXXIII. *Scrophulariaceæ*.—Although a number of species of this order have been obtained in the peninsula (see list), the individuals must either be rare or insignificant in Eastern Sinai, as they are unrepresented in the collections made. On the western side it was otherwise, the large and fine-flowered mullein (*Verbascum sinaicum*, Bth.) being one of the most conspicuous plants on the slopes of Mount Sinai when ascended by us in May, 1899.

XXXVIII. *Verbenaceæ*.—This order is represented by *Avicennia officinalis*, L. which, as already remarked, grows abundantly at isolated points on the shores of the Gulf of Akaba.

XXXIX. *Labiatæ*.—This order, next to the Compositæ, Leguminosæ, and Zygophyllaceæ, is the most important in Sinai, and is relatively more widely distributed than in the eastern desert of Egypt. Among

the larger mountain bushes the ghassa (*Otostegia Schimperi*, Bth.) is both conspicuous and common.

XLI. *Amarantaceæ*.—The *Aerua javanica*, Juss. is with its wooly head one of the most widely distributed of plants in the barren portions of the peninsula, and especially in the dark schistose region, where it alone relieves the otherwise absolute desolation.

XLII. *Chenopodiaceæ*.—This order includes three very important members of the Sinaitic flora, viz. *Haloxylon Schweinfurthi*, which fills the northern tributaries of Nasb, streaming from the sandy plain region ; *Anabasis setifera*, Moq., present on every important mountain summit, and *Suæda monæca*, Forsk. which is the characteristic Akaba shore-plant north of Noweiba.

XLIV. *Polygonaceæ*.—During the spring the young shoots of *Calligonum comosum* attract many gazelle to the lower reaches of Wadi Kyd, and it extends its range to the southern end of Sinai (Wadi Hashubi), where even the dried woody stems are a much-appreciated camel-food. On the other hand, *Rumex vesicarius*, L., which is of frequent occurrence, is welcome to the natives, having a taste strongly resembling the familiar sorrel.

LI. *Liliaceæ*.—Lilies are but poorly represented, *Asphodelus tenuifolius*, Cav., being limited to the central ranges.

LIV. *Palmæ*.—The presence of the date-palm (*Phœnix dactylifera*, L.) has been frequently mentioned in previous pages, it being always present in the more favoured spots.

LV. *Gramineæ*.—This important order has many representatives, but undoubtedly the most conspicuous is *Panicum turgidum*, Forsk. which was everywhere met with in suitable localities.

LIX. *Filices*.—The maiden-hair fern (*Adiantum Capillus veneris*, L.) grows near the small streams which lend a special beauty to the ravines of Isla, Hebran and Kyd, and is also sometimes found lining the small water-pools which are hidden away among the higher mountain-ranges.

Summary.

The principal conclusions are as follows:

1. The Sinai flora greatly resembles that of the eastern Egyptian desert, two-thirds of the species in the former area being common to the latter.

2. In Southern Sinai are a few Egyptian members not elsewhere present in the peninsula.

3. The distribution of characteristic plants is indicated, the following zones being recognized:—

a. High plateau (sandstone country) characterized by *Retama rætam* and *Haloxylon Schweinfurthi.*

b. Valleys of the mountainous or hilly central portion of South-East Sinai with *Iphiona scabra.*

c. An arid schistose sub-region in the above with only *Aerua javanica.*

d. The mountain summits with *Anabasis setifera* and *Pyrethrum santalinoides.*

e. The western plain with *Zygophyllum album* and species of *Aristida.*

f. The Akaba coast-plain with *Salvadora persica* and *Avicennia officinalis* in the bays.

g. The coral-reefs with *Anastatica hierochunthica.*

4. The *streaming* of the flora of the high plateau 3a along rift or fault-valleys into the region 3b.

5. A consideration of the principal natural orders in Eastern Sinai and their salient species.

Arabic Names of Principal Species mentioned in this Paper.

NATURAL ORDER	SPECIES	ARABIC NAME
Cruciferæ	*Matthiola arabica*, Boiss.	Khom-khom
do.	*Shouwia arabica*, D.C.	Nam-nam
do.	*Diplotaxis harra*, Forsk.	Harra
do.	*Zilla myagroides*, Forsk.	Bsilla
Capparidaceæ	*Capparis spinosa*, L.	Lassaf
do.	*? Cleome droserifolia*, Del.	Sommu
Resedaceæ	*Ochradenus baccatus*, Del.....	Gurdi
Silenaceæ	*Silene villosa*, Forsk.....	Kahali
do.	*Gypsophila Rokejeka*	Sirr

ARABIC NAMES OF PRINCIPAL SPECIES MENTIONED IN THIS PAPER, *(continued)*.

NATURAL ORDERS	SPECIES	ARABIC NAME
Paronychiaceæ	*Robbairea prostrata*, (Forsk.) Boiss	Enjiada
do.	*? Gymnocarpus decander*	Jeradeh
Tamariscaceæ	*Tamarix*, sp	Tarfa
Molluginaceæ	*Glinus*, sp	Lepetha
Malvaceæ	*Malva rotundifolia*, L	Khobbeyzeh
Geraniaceæ	*Erodium bryoniæfolium*, Boiss	Dahemi
Zygophyllaceæ	*Zygophyllum album*, L	Bowal
do.	*Nitraria tridentata*, Desf	Ghargad
Rhamnaceæ	*Zizyphus spina-christi*, L	Sidri
Leguminosæ	*Retama retam*, Forsk	Retem
do.	*Cassia obovata*, Collad	Senna
Cucurbitaceæ	*Citrullus colocynthis*, L	Handal
Umbelliferæ	*Zozimia absinthifolia*, Vent	Kalth
do.	*Deverra triradiata*, Hochst	Qasuch
do.	*Ferula sinaica*, Boiss	Shomer
Compositæ	*Iphiona scabra*, D.C	Dafara
do.	*Anthemis melampodina*, Del	Erbayan
do.	*Pyrethrum santalinoides*, D.C	Myrrh
do.	*Artemisia judaica*, L	Betheran
do.	*Senecio flavus*, Schnz	Wein
do.	*Zollikoferia spinosa*, Forsk	Kebad
Salvadoraceæ	*Salvadora persica*, Garcin	Arrak
Asclepiadeæ	*Gomphocarpus sinaicus*, Boiss	Hardjel
do.	*Calotropis procera*, Willd	Ashara
do.	*Leptadenia pyrotechnica*, Forsk	Markh
Borragineæ	*Trichodesma africanum*, L	Ekhmim
do.	*Anchusa Milleri*, Willd	Kahali
Convolvulaceæ	*Convolvulus hystrix*, Vahl	Shibrim
Solanaceæ	*Solanum retroflexum*	Anab-ed-dib
do.	*Lycium arabicum*, Schw	Ausedj
do.	Species of *Hyoscyamus*	Sekkeran
Verbenaceæ	*Avicennia officinalis*, L	Shora
Labiatæ	*Otostegia Schimperi*, Bth	Ghassah
Amarantaceæ	*Aerua javanica*, Juss	Ara
Chenopodiaceæ	*Haloxylon Schweinfurthi*, Aschers	Rimth
do.	*Anabasis setifera*, Moq	Hamr
Polygonaceæ	*Calligonum comosum*	Arta
do.	*Rumex vesicarius*, L	Hamatha
Liliaceæ	*Asphodelus tenuifolius*, Cav	Bowrag
Gramineæ	*Panicum turgidum*, Forsk	Theman

DISTRIBUTION OF NATURAL ORDER

NATURAL ORDER	No. of species in Eastern Desert	No. of species in Sinai	Species in Sinai not in E. desert	REMARKS
1. Menispermaceæ ..	1	0	0	
2. Papaveraceæ.....	2	1	1	
3. Fumariaceæ.....	1	1	0	Same species in both.
4. Cruciferæ	26	28	8	
5. Capparidaceæ....	6	7	0	
6. Resedaceæ.....	9	8	1	
7. Cistaceæ	4	4	1	
8. Silenaceæ	6	10	7	4 species peculiar to Sinai.
9. Alsineæ.....	3	5	4	3 species of this order appear to be invaders from the north.
10. Paronychiæ	10	11	1	
11. Molluginaceæ ...	2	2	0	Probably same species.
12. Tamariscineæ....	6	4	1	
13. Hypericineæ.....	0	1	1	Species peculiar to Sinai.
14. Malvaceæ	4	7	4	The special species peculiar to Sinai.
15. Fuliaceæ	6	1	1	do.
16. Zygophyllaceæ...	16	14	2	
17. Geraniaceæ.....	8	8	0	
18. Rutaceæ	1	1	0	
19. Rhamneæ	2	1	0	
20. Moringeæ	1	1	0	
21. Leguminosæ.....	34	45	11	7 of the special species are described from the Ord. Surv. Coll. and may be synonyms.
22. Rosaceæ	1	5	4	
23. Crassulaceæ	1	1	1	
24. Cucurbitaceæ	2	2	0	
25. Ficoideæ	5	1	0	
26. Umbelliferæ	5	6	4	3 species peculiar to Sinai.
27. Rubiaceæ	2	6	4	1 species peculiar to Sinai, the others from the north.
28. Dipsaceæ.....	1	3	3	3 species peculiar to Sinaitic peninsula.
29. Compositæ	66	59	15	
30. Campanulaceæ ..	1	1	1	
31. Salvadoraceæ	1	1	0	
32. Asclepiadeæ... .	5	7	1	
33. Borragineæ	18	21	3	
34. Convolvulaceæ....	5	4	1	
35. Solanaceæ.....	4	9	2	Seven Sinai species are known from Egypt, 3 being Delta or Mediterranean.
36. Scrophulariaceæ .	7	15	7	This order has a decided North African character in Sinai.
37. Orobanchaceæ ...	3	1	0	
38. Globulariaceæ ...	1	1	0	
39. Verbenaceæ	1	1	0	
40. Labiatæ.....	11	21	12	5 of the special forms are from Ord. Surv. Coll.

DISTRIBUTION OF NATURAL ORDERS—*continued.*

NATURAL ORDER	No. of species in Eastern Desert	No. of species in Sinai	Species in Sinai not in E. desert	REMARKS
41. Plantagineæ	8	4	1	
42. Nyctagineæ.....	0	2	1	
43. Amarantaceæ .. .	1	1	0	
44. Chenopodiaceæ...	23	19	1	
45. Polygonaceæ	4	3	0	
46. Euphorbiaceæ ...	5	9	2	
47. Urticaceæ	3	3	0	
48. Salicineæ.....	0	1	1	
49. Gnetaceæ	2	2	1	
50. Hydrocharitaceæ.	0	1	0	
51. Asparagaceæ	1	1	1	
52. Liliaceæ.....	5	7	3	
53. Colchicaceæ	1	4	4	Chiefly in North Sinai.
54. Juncaceæ	1	3	2	
55. Palmæ.....	1	2	1	*Hyphæne* at Tor only.
56. Naiadaceæ.....	0	5	5	
57. Cyperaceæ	2	3	1	
58. Gramineæ.....	39	40	9	
59. Equisetaceæ	0	1	1	
60. Felices.....	1	3	1	
TOTAL....	379	439	135	

CHAPTER V.

ZOOLOGICAL NOTES.

In the account of the Ordnance Survey of the Sinai Peninsula, 1869, p. 253, et seq., Mr. C. W. Wyatt has given a detailed description of the fauna met with in the western half of the peninsula, with which, as will be seen from the subjoined notes, the eastern portion agrees in all essential particulars. These zoological observations are necessarily of a general character, the objects of the expedition and rapidity of traverse being unfavourable to the formation of a systematic collection.

The most important of the Sinai mammalia is undoubtedly the Leopard (*Felis leopardus*)—arab. nimr,—which, though common to both sides of the central chain, is most widely distributed in the eastern ranges near the Gulf of Akaba, where it finds a congenial home in the secluded mountain fastnesses. Being of nocturnal habit, these animals are

seldom seen, though the freshness of their tracks near the camps in Wadi Aad and the Ferani range gave constant evidence of their close proximity. While we were encamped in Wadi Nasb, the destructive character of these animals was well exemplified, five camels having been killed by them in the immediate neighbourhood. On two other occasions Arabs forming part of the expedition observed them in the hills above Wadi Isla, and again in the Ferani range, in both cases at sundown.

No less widely distributed is the *Hyaena striata*, arab. dubha, whose dens are most frequently met with beneath the huge boulders scattered among the low granite hills near the Gulf of Akaba. So far as could be ascertained, foxes and jackals appear to be entirely absent.

The Ibex (*Capra nubiana*) Arab. tetel.—Of all the Mammalia in the Peninsula of Sinai the ibex is undoubtedly the most characteristic, and was the one most frequently met with by the expedition during mountain ascents. They could often be approached at very close quarters, but as a rule when suspecting danger they climb the highest summits, whence they can command the most extensive view of the surrounding country. A prolonged period of rain is unfavourable to the ibex hunter, there being then an ample supply of water in the pools of the highest valleys. On the other hand, during seasons of drought, they descend into the lower valleys (Wadi Nasb, etc.) when they can be more easily approached. These animals were often observed in herds of five to ten, and when feeding it was evident that the females acted as sentinels, the males browsing peacefully till warned of danger by their alert companions.

Dorcas Gazelle, Arab. ghazal.—The general statement made by Wyatt, that these gazelle are never found in the mountains must be some what modified, they having been observed some distance from the plains among the mountains, though as a rule in valleys rich in vegetation, where as many as fifteen have been noted in one herd. It is, however, perfectly true that, unless under stress of circumstances, these graceful animals avoid ascending the hills themselves.

Coney (*Procavia syriaca*) Arab. Wobur.—This animal is common to both Sinai and the Eastern Desert, its occurrence in both localities having been already described by the writer in a former Survey memoir. (See "Topography and Geology of the Eastern Desert of Egypt, Central portion," p. 107).

The Hare.—Arab. arneb, presumably *Lepus sinaiticus*, though not common, was observed on two occasions.

A notable absentee is the Jerboa, but the rodents are represented by Jerbils and a few mice. Wyatt mentions *Gerbillus pyrargus*, Cuv.?

HYENA DEN NEAR WADI KYD

the Lerat *(Myoxus quercinus)*, the Porcupine Mouse *(Acomys dimidiatus.* Rüpp.), *Acomys russatus*, Wagn., and *Acomys cahirrhius*, Geoffr.

Birds.—One of the commonest of the birds observed soaring above the mountain crests was the Egyptian vulture, *(Neophron percnopterus*, Linn.) which served on many an occasion as a useful guide, its flight above the ridge indicating from a distance the presence of the members of the main party, even though these were themselves invisible to the observer in the valley below or on some neighbouring crest. Eagles are probably also present in the same valleys, especially near Gebel Tha'albi, but as none were actually shot, their occurrence is not absolutely proved. Wyatt states that these birds are rare in the peninsula, but Barron noted them in numbers on one occasion, when a leopard had killed both a camel and eagle.

In Wadi Letih, a small owl (probably *Athene meridionalis*, Risso) was observed, which drew the remark from one of our guides "that it was a bird of ill omen, having an evil eye, and if it should flutter behind the head of a man during his sleep, from that day forward misfortune and illness would continually attend him." Wyatt records the presence of the Common Cuckoo *(Cuculus canorus*, Linn.), and the European Bee-eater *(Merops apiaster*, Linn.) from Wadi el Hudera and El Noweiba respectively, but regards them as being mainly birds of passage. The Common Swallow *(Hirundo rustica)* was observed at the latter locality early in April, evidently migrating.

Of the smaller birds, the Chats (*Saxicolas*) with their black and white plumage, are both the most striking and most frequent visitors to the camp, their song also being very melodious. The White Wagtail *(Motacilla alba*, Linn.) showed its friendly disposition by its frequent visits, even entering the tents, and its presence was always welcome in a land where, in general, life is so conspicuously absent.

The Larks are also probably as frequent as in the eastern desert, but the fact that they appeared as customary objects in the landscape rendered them less noticeable than some of the rarer but more striking species.

Among the common birds is a species of Crow, which was often seen perched on the backs of the camels while these were feeding, and the Raven (*Corvus umbrinus*)—arab. ghorab.,—which was especially noticeable in the granite crags above Wadi Nasb.

Of the game birds the most frequent and most welcome to the traveller as supplying an addition to his commissariat is the Hey's

Partridge, which, with its neutral protective colouring, is difficult to distinguish as it runs rapidly along the rocky slopes which bound the valleys. Of the migrating birds, the only one observed was a Crane-like species which crossed the peninsula during the spring months in enormous numbers, often flying at great heights. Their direction of flight was mainly from west to east, confirming the statement on p. 110, "Eastern Desert Survey Report," where reference is made to the passage of the Red Sea from Gharib to the Sinai coast north of Tor by large flocks of these birds, similar flights being observed near Ain el Hudera in May. Two birds are mentioned in the Ordnance Survey report, as having this habit, viz.: the Common Crane (*Grus cinerea*, Bechst.), and White Stork (*Ciconia alba*, Bechst.), Although not near enough to be recognised, from their appearance and manner of flight these were most probably the first-named species. The vertebrate fauna of the eastern side of the peninsula seems, indeed, to be of a very limited description, and so far as could be judged its other members (*Reptilia*, etc.) do not differ very materially from those already mentioned in the Eastern Desert Report. Lizards were everywhere abundant in those valleys where bush life was at all common, and snakes, especially one of the hornless flat-headed *Cerastes*, became increasingly frequent as the spring advanced, while a thin whip-like species was generally present in the water-holes.

But all observations made point to one conclusion already emphasized by the writer in the Eastern Desert Memoir, viz: that both as regards their flora and fauna (whether vertebrate or invertebrate) the Eastern Desert of Egypt and the Peninsula of Sinai form part of one life province, differing only in a few details (See table on p. 108, "Eastern Desert Report.")

Turning to the separate orders and sub-orders of Invertebrata, the following observations of a general character may be of interest to future travellers.

Of the Arachnida, the Acarine (Mites) are very prominently represented by the camel-tick, which infests the main tracks, and by its parasitic habits is troublesome alike to man and camel. Owing to some unknown cause, which leads the Arabs to throw them away instead of killing them after removal from the camels, they are in great numbers, no less than fifteen having on one occasion been noted in one spot.

Their persistence in tracking their victims is remarkable, and it was often amusing to let them approach, and then lightly stepping over them, to watch the puzzled halt to which they were suddenly brought, the advance being again renewed on rediscovering the object of their

attack. While true spiders and scorpions appear to be rare, only one of the latter having been observed at the head of Um Shoka, the Solifugæ, or false spiders, (especially *Galeodes*, which attains a large size) are numerous. These being of nocturnal habit were often seen after sunset running about the tents with great rapidity. Although in the Sudan the Arabs consider their bite to be poisonous, this opinion is not shared by those in Sinai. Turning to the orders of the Insecta, the Orthoptera are especially represented by the carnivorous Mantidæ, or leafinsects, of which three species have been noted in Sinai.

One of these is the conspicuous form whose bright-green elytrae exactly resemble the leaves of trees, another has a very thin body like a twig, while the third is shorter and thicker, in colour remarkably akin to its habitat the desert, and probably an *Eremiophilas*. The latter is invariably found in the coral reef area, which is almost destitute of vegetation. The Orthoptera Saltatoria are very prominently represented by a large species of locust, which flew in and over the mountain valleys in considerable numbers, their wings shimmering, delicately iridescent, in the sunlight. Their distribution was no doubt to a large extent dependent on the prevailing north-east wind, which tended to drive them towards the centre of the peninsula. May-flies (*Ephemeridæ*) and the Dragon-flies (*Libellulidæ*) are most noticeable, the latter being especially prominent round the shallow pools in the larger valleys. The Rhynchota are represented by a *Cicada*, which in the spring is very abundant in the tamarisk trees, on whose young shoots it feeds. Its puncture causes a sweet gum to exude, which on hardening forms the "man" of the Arabs.

The more familiar members of the Diptera, viz: flies, fleas, and mosquitoes were not much in evidence in the mountains, this being probably due to the expedition having been undertaken in the main during the winter months; in the plains both flies and mosquitoes are apt to be a source of annoyance. Lepidoptera (Butterflies and Moths) are represented, but as in the Eastern Desert, they are not numerous, and though collections made at certain spots might be rich in individual specimens, the number of species would probably be few.

The Coleoptera of the Ordnance Survey have been examined by G. R. Crotch, who gives a list of 128 species taken by Mr. Palmer, 15 being described as new. "Of these, 26 appear to be peculiar to the district, while only 10 are common to Europe generally, 20 are found all along the borders of the Mediterranean, while the remainder are confined to Syria and Egypt.

Hemprich and Ehrenberg appear to have been the first to have made any systematic collection in the district, the species obtained by them being now in the Berlin Museum. Crotch states that "the most marked group is perhaps that of the Hydradephaga, where all the species appear to be peculiar. The extreme isolation of the scanty water supplies may perhaps account in some degree for this. The comparatively large proportion of the coprophagous species (in the list) is no doubt to be explained by the universality of their pabulum, and by the little search requisite for them. Next to these, or even more numerous, are the Tenebrionidæ, which at once mark out the desert character of the fauna, especially when contrasted with the almost utter absence of the Phytophaga. It is in the Tenebrionidæ that I have found the greatest number of new species, some of which are of extreme interest. The little genus of nocturnal Lamellicornes, *Pachydema*, also would seem to be probably rich in species in the desert, for the four described are all very closely allied to *P. Saulcyi*, Reiche, though abundantly distinct from it." Reference is also made to the magnificent series of 170,000 specimens collected by M. Ch. Piochard de la Brûlerie in Syria and Palestine.*

The most prominent of the Hymenoptera are the hornets and ants, the former being especially abundant on a markh bush in Wadi Gnai, while the latter are ubiquitous in their distribution. The traveller in Sinai, if sleeping on the ground, is liable to much annoyance from these insects, which in serried masses invade the tents; on one occasion they could only be stopped by digging trenches, and burying the invaders as they advanced, and on another a long unbroken band of these insects was observed stretching across the broad valley of Sa'al.

CHAPTER VI.

ECONOMIC NOTES.

A very deep interest has been evident during the last few years in the revival of the ancient mining industry which formerly existed in the Eastern Desert of Egypt, and although during the preliminary studies in Eastern Sinai no actual gold mines have been discovered, the occurrence of ancient copper workings at widely separated localities

* A valuable collection of insects has recently been made by Herr Guyot, but the results have not yet been fully worked out.

and the similarity which exists between the rocks of Sinai and the Egyptian Desert, warrant the assumption that gold may also be found in the peninsula.

In Egypt proper between the 22nd and 28th parallels of north latitude *Gold* is now known to be widely distributed in both the older sedimentary and plutonic rocks, and more especially in the neighbourhood of, or actually in the less acid granites (hornblende-granites), quartz-diorites, and diorites which often appear to form well-defined zones, near the junction of the granites with the ancient sedimentaries. As rocks of the last-named type are largely developed in Eastern Sinai, (see appended maps), it is hoped that a record of their distribution may prove of material aid to the prospector.

In many cases despite the large number of ancient workings, it has been most difficult to obtain even traces of *Gold* at the surface, but deeper excavations have led to the finding of rich ore bodies in some of the Egyptian mines. The want of superficial deposits is largely accounted for by the removal of the outcrops and weathered portions of auriferous bodies by the ancients, and in any case patient search and study of the various formations has been necessary to locate the old shutes; such work does not come within the functions of a rapid geological survey, whose object must be to lay a wide general foundation on which more detailed research may be based.

Summarizing with regard to the occurrence of gold in Sinai it may be stated :—

1. That the similarity of the formations to those of the Eastern Deserts of Egypt is a hopeful indication that auriferous deposits will occur.

2. Only a systematic search by prospectors can prove the existence or non-existence of gold.

3. In concluding this note on gold the quartz region near the foot of Gebel Abu Mesud may be indicated as one of the most likely spots at which to commence such an exploration.

From time to time expeditions have been made by various exploring parties into the Sinai Peninsula, but unfortunately but little of their data has been published.

The following lines are inserted here to draw attention to a few facts or statements which have been made by these explorers; the opinions expressed have been more or less indefinite, and are therefore excluded from this Report. Some of the verbal information which has been given to the writer from time to time leads him to suppose that there

exist many ancient mining centres for copper, but without having had an opportunity to corroborate such evidence, it is scarcely within his competence to insert the same here.

Referring to the analysis of samples included in this Report, it must be noted that these are merely surface specimens broken off from formations noticed during a rapid reconnaisance survey, and are not intended to indicate the relative values of such, but the analyses warrant the hope that there may be extensive formations which, under suitable conditions, may prove of commercial value and at least are interesting as proving that various mineral products do exist in the Sinai Peninsula.

Copper.—Whereas the probability of the discovery of gold can only be inferred, ores of *Copper* are certainly present, not only on the western, but also on the eastern side of the peninsula. This is notably the case in the neighbourhood of the plain of Senned, near Wadi Khosh Dhaba, where workings were discovered by Mr. Holland in 1868 (position shown on Ordnance Survey map). He states (p. 224 of the Ordnance Survey Report), that "my attention was attracted by numerous small pieces of blue carbonate of copper which had evidently been brought there. I traced them up to the foot of a rock, and finding that they ceased, I dug a hole there, and came upon a slag heap and broken twyers exactly similar to those found at Wady Nasb. My Arab, Salem, then told me that he could take me to the place where the blue stones came from, and he conducted me to a dyke which had been excavated more or less for a distance of nearly two miles, and which was exceedingly rich in the blue carbonate. The circumstance of this dyke occurring in the syenite renders it probable that the ore smelted at the other places named was found in the same rock."

Holland also made an interesting discovery "in a curious way in 1868, on the coast of the Gulf of Akaba, almost opposite the island of Tiran. As I was walking down the coast and crossing a watercourse I picked up two flakes of flint. This led me to trace up the watercourse to a low hill, on which I found several heaps of slag and other flints. There was also a good deal of copper here. A little north of Sherm I once found several pieces of carbonate of copper in a wady bed, but was not able to follow it up. It is possible that the ore came from there."

The writer of this memoir had a similar experience, finding numerous pieces of copper slag on a raised coral reef near the sea a little south of Nebk, an occurrence which led to this mineral being kept

specially in view during this portion of the work, and to the general conclusion that copper ores were present in the hills to the west of the plain between Nebk and Sherm.

Near Nebk in the Wadi Samra a syndicate did for a time conduct prospecting operations, but these have since been abandoned. Some specimens of silicate of copper coming from this spot are exhibited in the Geological Museum of Cairo.

The above are the two regions in Eastern Sinai where copper ores have been recorded, but those on the western side have attracted most attention, both in ancient and modern times. Visited by Rüppell,* in 1822, on behalf of Mehemet Ali Pasha, he located them near Wadi Nasb, in lat. 29° 8′ north and 50° 55′ E. long. Here enormous workings were found in the sandstone, and a sample smelted yielded 18 per cent. of pure copper, the same amount being found in the ferruginous slag produced, while a garlic odour emitted during the operation suggested the presence of arsenical compounds.

Rüssegger,† when passing this locality in 1838, was not aware of the existence of copper ores, but discovered the presence of iron and manganese deposits in the sandstone, which had obviously been worked in ancient times.

In 1845 Lepsius found copper-bearing sandstone and fragments of copper at Bir Nasb, but was unable to trace the workings described by Rüppell.

The general results obtained were analyzed by Dr. Fr. Gensler,‡ who concluded:—

1. The minerals of economic value in Sinai were copper, iron and manganese ores, speissglanz, and turquoise.

2. Only the copper ores could be regarded as of considerable, in fact of uncommon development (in beträchtlicher, ja in ungewöhnlich grosser Mächtigkeit kommen dort *nur* Kupfererzlager vor). In Wadi Nasb these are visible, and their presence in Wadi Maghara may be inferred in view of the specimens obtained by Lepsius.

From the archæological study of the famous inscriptions at Sarabit el Khadim it is highly probable that the word "Mafkat," therein so frequently repeated refers to copper, and that the Egyptians had made this metal the main object of their research. It is of deep interest to notice that while Mafkat is the only mineral described in an inscription

* RÜPPELL: "Reise in Nubien, etc." p. 264, 1822.

† RÜSSEGGER, "Reise in Unterägypten, auf dem Halbinsel Sinai, &c." p. 225, &c.

‡ "Zeitschrift für Aegyptische Sprache" Oct., Nov. 1870, p. 137-150.

of Amenemhat III.* at Sarabit el Khadim, in another of Rameses III.† enumerating the products of the land of Punt or Arabia Petræa, Mafkat is omitted, only *Rami anta* (gum) and *jut* (wood) being mentioned. It is also noticeable that the last record on the plateau of Sarabit el Khadim dates from the reign of the last king of the 19th dynasty, while‡ the 20th begins with Rameses III; it therefore appears probable that this warlike monarch abandoned the mines owing to increasing difficulties in connection with fuel, obtaining his supplies from other sources. The general discussion as to the reasons why Mafkat should be regarded as pure copper will be found in Dr. Gensler's paper above-mentioned.

Holland (loc. cit. p. 224) has suggested that this copper-ore may have been used solely for producing the beautiful blue glazes of the Egyptian ware, but the importance of "Mafkat" in the inscriptions, where it takes fourth place in the lists of minerals given, being only preceded by gold, silver, and "chebset," points rather to actual metallic copper having been the quest. Other localities for copper slag have been noted by Holland, and in 1898-99 the district was re-visited by Barron, of the Geological Survey of Egypt, who has dealt with this question in his memoir on Western Sinai.

It will be seen from the above remarks that copper ores play an important part in Sinai, and are more especially developed at three points:—

1. In the neighbourhood of the northern Wadi Nasb.
2. Near the plain of Senned.
3. In the hills west of the Nebk-Sherm plain.

Manganese.—In addition to the copper ores, Sinai is known to contain those of iron and manganese, these being especially developed on the western side of Sinai, where they have been studied by Barron. The analyses of the samples collected by him from Wadis Malha and Hallig (see attached list) show manganese ores with over 60 per cent. of manganese. On the eastern side no such percentages have been obtained, though one of the occurrences is of considerable interest. As remarked elsewhere, the cliffs at Sherm are remarkable for their peculiar colouring, and an examination showed that they were composed of pebbles cemented by the hydrated oxide of manganese,

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* LEPSIUS, "Denkmaler II." 144 q. lin. 7.

† LEPSIUS, "Denkmaler III." 210. a.

‡ LEPSIUS. "Briefe aus Aegypten," p. 537.

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psilomelane. Of this deposit typical samples have been analyzed by Lucas with the following results:

I. Manganiferous gravel from summit of cliff above Sherm.

II. Ferruginous bed, base of manganiferous gravel, Sherm.

	I.	II.
	%	%
Silica and insoluble	54·78	70·10
Iron and aluminium oxides	2·32	12·92
Manganese dioxide	30·33*	12·67
Lime	trace	trace
Magnesia	nil	trace
Loss on Ignition	9·48	5·06
	96·91	100·75

In view of the frequent presence of *Cobalt* in association with psilomelane, the former was specially sought for, but proved to be entirely absent.

This manganiferous deposit caps the cliff which borders the southern end of Sherm harbour and the large bay to the south; it probably has a certain extension inland, naturally suggesting the presence of some rich manganese-bearing area, now hidden under the granite detritus which covers the plateau west of Sherm. The flying traverses taken across the plateau failed to locate such beds *in situ*.

When ascending Gebel Ashara, psilomelane was obtained in a vein traversing the granite, the analysis yielding the following result:—

	%
Silica and insoluble	40·42
Iron and aluminium oxides	4·92
Manganese dioxide	50·04
Lime	trace.
Magnesia	,,
Loss on Ignition	9·46
	104·84†

It may therefore be generally stated:—

1° Manganese dioxide is present in the granite of the Sinai region.

2° By concentration it has given rise to deposits rich in the oxides, two districts being especially conspicuous:—

(*a*) In Western Sinai, in Wadis Malha and Hallig, where, as shown by Barron, rich ores are present near the junction of the Carboniferous limestone and sandstone, largely existing as pockets.

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* Manganese 19·16 %.

† Lucas notes that a small part of the manganese evidently exists in a lower state of oxidation than the dioxide, thus accounting for the percentage result.

(*b*) In Eastern Sinai, at Sherm, where hydrated manganese oxide forms the cementing material of the gravels. Owing to the high percentage of silica (quartz) as sand, concentration would probably considerably enrich the product.

Iron.—In intimate association with the manganese ores of Western Sinai are iron ores, samples of which show high percentages, and include both the kidney and the micaceous varieties. Whereas in Wadis Malha and the northern Nasb and its neighbourhood, these ores occur, as above stated, near the junction of the Carboniferous limestone and sandstone, in Eastern Sinai they are present in the quartz veins which seam the granite near the foot of Gebel Abu Mesud, being there mainly in the form of micaceous hæmatite. The samples collected at this spot yielded the following analyses.

I. Magnetite from Wady Um Agraf:

	%	
Silica and insoluble	3·42	
Oxide of iron	96·25	=67·37 % iron
Oxide of aluminium	trace.	
Lime	„	
Magnesia	„	
	99·67	

II. Hæmatite in quartz vein, Wadi Um Agraf:

	%
Silica and insoluble	40·77
Iron and aluminium oxides	59·25
Lime	nil.
Magnesia	trace.
Loss on Ignition	0·59
	100.61

III. Limonite in quartz vein, Wadi Um Agraf:

	%
Silica and insoluble	4·90
Oxide of iron	92·20
Oxide of aluminium	trace.
Lime	„
Magnesia	„
Loss on Ignition	2·82
	99·92

There are therefore two regions in Sinai where iron ores have been shown to be present:—

1. In Western Sinai, in the neighbourhood of the northern Wadi Nasb, at the junction of the Carboniferous limestone and sandstone.

2. In Eastern Sinai in the region to the west of Gebel Abu Mesud, where they are present in quartz veins seaming the granite.

Water supply.—The rainfall in Sinai being more abundant than that of the Eastern Desert, the water question here is of minor importance, those exploring the region readily obtaining supplies in the granite hills or from the three well-known wells at Dahab, Sherm, and Nebk. Similarly for expeditions in the northern part of this area the oases at El Ain and Ain El Hudera supply excellent drinking water from perennial fault-springs.

In addition to the rock-pools in the granite, shallow diggings or wells in the larger valleys usually yield good results, and on the seashore there seems to be a tendency for the underground water to be ponded back at the point where the large drainage lines enter the sea. There are actual surface streams in Wadis Isla, Nasb, Kyd, and Hebran, springs in the oases already mentioned, wells at Noweiba, Dahab, Nebk, and Sherm, and should the last-named be dry, an exceptionally well-protected water-supply exists at the head of Wadi Aad. If information as to further details be required, it will be found by referring to "Waterpools" in the index.

The chief water difficulty arises in visiting the barren schistose district between Dahab and Nebk, the sandstone region south of Ain el Hudera, and the sand-swept area near Ras Mohammed.

Sands.– In most civilized countries the pure white sands of the Upper Nubian sandstone, which are sometimes over 100 metres thick, would be of value in connection with glass manufacture, but in view of their isolated position, are of no importance from a practical point of view.

Building stones.—The same statement holds good for the exploitation of building stones, there being an inexhaustible supply of granites, felsites, and gneisses, and some of them, like the delicate gneiss of Gebel Heyala, are very beautiful. On the other hand some highly characteristic rocks of the eastern desert of Egypt, notably the imperial porphyry, have not up to the present been recorded from Sinai.

Gum.—Gum appears formerly to have been an important product of Sinai, but has ceased to be so owing to the wholesale destruction of the gum-bearing acacias for the manufacture of charcoal, these trees being only now present in small numbers at the foot of the granite hills or in the main valleys. In view of the large supply of this product from the Sudan, it is very unlikely that even extended replanting would yield any results of economic value.

II.—GEOLOGY.

Speaking in the broadest sense, the geological structure of Eastern Sinai is comparatively simple, the hill districts of the southern portion being entirely composed of igneous and metamorphic rocks; north of Wadi Nasb these are capped by Nubian sandstone, which itself is overlaid by limestones of Cenomanian age. Owing to faulting and rift formation, this simple succession is, however, considerably disturbed, the result being the production of extremely complex topographical conditions. The most important feature outside the hill-region is the plain between Nebk and Sherm, in which, in addition to the superficial gravel deposits and coral reef, are some important strata of Miocene age. In addition, a large number of interesting beds of gravel occur in the mountain valleys.

The geology will be treated under the following heads:

Chapter VIII.—Pebble gravels, travertine, etc.
„ IX.—Coral-reefs.
„ X.—Miocene strata.
„ XI.—Cretaceous limestones of Cenomanian age and Nubian sandstone.
„ XII.—Igneous rocks.
„ XIII —Ancient sedimentaries and contact changes.

CHAPTER VII.

PEBBLE GRAVELS, TRAVERTINE, ETC.

A.—Pebble gravels and Travertine.

Nothing will strike the observant traveller more forcibly on entering the narrow gorges in the Sinai hills than the great development of terraces of gravel in the principal valleys, these being often over 20 metres in height, and composed either of materials of different consistency very roughly stratified, or still more often of the debris of

the igneous hills mixed together in a more or less chaotic manner. Fraas was especially impressed by these occurrences, which he could only presume were the moraines left by former glaciers (though as to their age he could say nothing), an idea which is not really so far-fetched as might appear, as even at the present time snow lingers on the summits of the Sinai hills, sometimes for days together. Thus in December 1898, when we ascended Gebel Sabbagh, it was covered with a coating of snow which had not disappeared after several days of sunshine, the temperature at the summit at midday barely exceeding 0° Centigrade. If the temperature here were reduced to the same extent as it would be in Europe during the Glacial Period, a small amount of névé would have accumulated in the higher mountains, and the increased torrent-action resulting therefrom might well have been a factor in the formation of these deposits.

When Wadi Isla leaves the hills and enters the plain of El Qa'a it is continued for a short distance between cliffs of boulders 10 metres high, clearly showing that denudation now exceeds deposition, and indirectly proving that the area had undergone elevation. At points where the valley expands, or near the entry of side-valleys, as opposite Wadi Emlaha, the same cliffs of pebble-gravels are present, generally cut back into a vertical precipice consisting of boulders of the igneous rocks of the district of the most varied forms and sizes. These gravels extend far over the plain of El Qa'a towards Tor, where they are found capping the salty marls and gypseous limestones at El Wadi near that town.

Wadi Nasb.—These beds again reappear on the other side of the watershed in Wadi Nasb and its tributaries, being especially noticeable up Wadi Hezaima and where Wadi Harban enters the Nasb defile, at the latter point being at least 30 metres high, and crowned with remains of ancient buildings.

Um Girhat terraces.—At the end of the first Nasb ravine, where it is crossed by the Um Girhat-Rachal rift, the terraces again form a low plateau on the northern side, serving as an excellent camping-ground, and are also well developed between the drainage lines of Wadis Kherait and Matershat which cut obliquely across the Um Girhat depression.

Wadi Hamra.—While the main gorge of Wadi Nasb contains but little trace of their existence, they are again prominent in the hill-districts to the south, as in Wadi Hamra at the base of Gebel Ashara.

Other points in the mountains at which important terraces of these gravels occur (which also form good camping grounds) are the following: at the junction of the Wadis Ethmoi and Kyd, the gravels lying in the angle between these two valleys; at the foot of Gebel Gazala, where Wadi El Ghim joins Kyd, and also to the west of this point, bounding Wadi Kyd itself; at the junction of Wadis Marua and Humr, and especially well marked at the base of the higher ranges in Wadi Ethmoi. On issuing into the sea-coast plain north of Nebk, these beds are found overlying coral limestone at Ras Atantur, rounded pieces of granite and schist being also mixed with the Astræan corals, *Laganum*, *Tridacna*, etc., which form the summit of the reef. These gravels, which from this locality dip gently to the south-west and occupy the plain region up to the foot of the hills, are consequently not earlier than Pleistocene in age.

Terraces at mouth of Wadi Kyd.—At the mouth of Wadi Kyd are two remarkable flat-topped terraces at levels of 23 metres and 31 metres respectively, and also traces of a third at a still greater elevation are visible. These consist of a thin deposit of pebbles and boulders (many of which are over a metre in diameter) lying on the older rocks; those of granitic origin rest mainly on the slopes, while the dark basic rocks are spread on their upper surfaces. It seems difficult to account for these characteristics except on the assumption that they are in reality a series of raised beaches, whose presence at these levels suggests recent elevation of the whole district.

Higher up Wadi Kyd there is a gravel ridge stretching halfway across the valley at a point where El Beda joins it from the west, Wadi Kyd forming two branches which pass round it and reunite on the southern side. Similar terraces are met with in the higher valleys to the south, notably at the head of Wadis Yahamed, Sabbagh, Um Adowi, and forming the Jeraif plateau, while in many of the side-valleys (Um Ekhlis, etc.) they are also present.

Sufficient has been said to show that these beds occur practically throughout the igneous hill region, especially at the heads of the main valleys and their junction with the minor tributaries. These are probably not older than the Pleistocene, as they overlie coral reef containing Pleistocene shells, and are characterized by the fact that they contain fragments of all shapes and sizes derived from the surrounding hills, which are imbedded in a sandy matrix consisting of material of the same derivation, the source being thus strictly local.

GRAVEL TERRACE AT MOUTH OF WADI BUDR.

With regard to the question of their origin, it is only possible to suggest considerations, the theory which commends itself to the writer involving a combination of two circumstances, viz., the earth movements of which the region shows such abundant evidence, and a great rainfall.

The earth-movements might very readily have resulted in temporary ponding back of the mountain torrents, when it is recalled that the greater part of South-eastern Sinai is even now almost a closed system, bounded on three sides by mountainous watersheds, only one of which is broken through by two valleys. With regard to the question of greater rainfall, it need only be noted that at the present day the storms, though frequent in winter, are of short duration, and the resulting torrents are active in the work of erosion rather than of deposition, these being chiefly engaged in filling the smaller valleys with confused masses of huge boulders, such as will be familiar to every traveller who has climbed the mountains of the peninsula.

But one of the most striking features connected with these gravel plateaux is the perfectly flat nature of their upper surface even in the upland wadis, a character quite inconsistent with their having been produced by rushing torrents, but in accordance with the hypothesis of their formation in ponded-back lakes or marine fjords. The apparent absence of any marine shells renders it probable that the detrital beds of the central portion of Sinai are due to deposition of the material derived from the surrounding hills in lakes, rather than to their accumulation in arms of the sea. Whatever theory may finally gain acceptance must take account of their extensive distribution, and the height at which they are now found, they sometimes being 1200 metres above sea-level.

B.—Manganiferous Pebble Gravels.

While the majority of the bays of the Akaba coast are broad inlets of the sea, running into the land between the yellowish-white limestone cliffs of the raised coral series, Sherm is at once distinguished by the red and black colouring of the scarp commanding the bay to the west and south. This exceptional appearance is due to the presence of a conglomerate, whose constituents are *cemented by the hydrous black oxide of manganese*, psilomelane, in places as much as four metres thick, while underneath are beds coloured red by ferruginous ochre. These gravels are closely connected with a core of red granite, stopping abruptly where the latter is no longer exposed at the surface to the north with the result that the northern cliff is of a totally different

character, consisting of coral-reef forming a cap to sand-rock of varied tints. The manganiferous gravels only seem to be connected with and overlie the granite at the point where the latter faces the sea, extending but a short distance up the valleys and not being found south of the transverse chain of Zafara, which rises abruptly from the plain. This hill, consisting of sand-rock mainly derived from granite associated with massive beds of sandy limestone, presents a difficult geological problem, owing to the absence of fossils by which its age might be determined. Although the manganese beds are closely associated with the granite, and possibly owe their origin to the re-arrangement of Nubian ferruginous sands immediately overlying the latter, direct proof in favour of this hypothesis is wanting, though sands of presumably Nubian age form the base of the northern cliffs of Sherm bay. It is also interesting to note that the Austrian S.S. "Pola" expedition found manganiferous deposits forming on the floor of the Gulf of Akaba itself, the presence of these manganiferous beds suggesting the occurrence of important manganese deposits west of Sherm, but our studies in that region have not brought such to light, and the gravel bed may be the result of their complete denudation.

C.—Oolitic Valley Deposits.

Walther (*Die Korallenriffe der Sinai Halbinsel*, Bd. XIV. Abhandl. math.-phys. Königl. Sächs. *Gesellschaft des Wissenschaften*, pp. 481-484,) calls attention to the fact that near Suez and especially on the border of the Kyd desert he found oolitic grains, while he had nowhere noted oolitic rocks either in Sinai or in the Arabian desert. From his examination he concludes that these grains met with especially at the mouth of Wadi Dehese are really a recent formation in *statu nascendi*. A closer examination showed him that these consisted of quartz-grains enclosed in a calcareous layer, and that when several zones were present there was a darker band between the inner dark-yellow and outer clear shell of calcite. Amongst the minerals noted as nuclei were felspar, garnet, magnetite, and fragments of foraminifera. His conclusion is that the mineral grains come from the desert and have been carried by land-winds into the shallow sea, where various small animals would play their part in assisting the formation of the calcareous coatings. These interesting observations can now be extended, as an oolitic rock of this very nature is most extensively developed among the hills north of Ras Mohammed, where it forms a striking light-coloured oolitic calcareous sandstone bounding Wadi

Hashubi, and almost filling the small tributary valleys, which are reduced in many cases to narrow cañon-like ravines. Walther has mapped this as Dünensandstein of Hashubi. As it is the most striking deposit in this neighbourhood, it naturally attracted special notice, and it may be therefore interesting to give the notes as they were made on the ground, stating first that these were written without knowledge of Walther's result, his paper being at the time with the party working in West Sinai. The facts noted in connection with it are:

1. The sand-rock consists of quartz and orthoclase grains similar to those of the wind-blown sand in the neighbourhood cemented by carbonate of lime, which in many places surrounds them in a series of calcareous coats. 2. These strata dip in every direction, being often plastered against the sides of the hills, or forming horizontal beds cut down vertically in the gullies. Further, the sandstone forms the sides of Wadi Hashubi and every one of its tributary valleys, the ridges of moderately coarse biotite-granite underlying it, or dykes of dolerite rising through it like islands. In this area the sandstone varies in dip from horizontal to about 5° and *shows* in places *traces* of *ripple-marking* and *very fine sun-cracks*, numerous long tubular cavities, and somewhat questionable rain-prints, showing maximum depression towards the south. The sandrock has covered the ridge running south of Wadi Hashubi, and near its summit shows a remarkable fault-like structure, beds dipping 25° S. resting against horizontal strata, and being due probably to local slipping. In the lower part of Wadi Hashubi it is very thick and horizontal, in some places being strongly current-bedded and containing lenticular masses of pebbles. The dip it shows when overlying the surface of the igneous rock is probably due to slipping of once horizontal beds worn away below, and the sandrock has a peculiar habit of weathering internally, a thin external wall pierced by small holes masking a larger internal cavity. Here well-defined pebble beds overlie this formation, which itself rests on a floor of granite.

Similar strata were found to be present in the small side-valleys of the lower igneous hills to the north of Hashubi, the main valleys being filled with long ridges of the igneous gravels. In a groove at the foot of Gebel Hedemia the sandrock forms cliffs about 10 metres high, but is coarser in its composition than that of Hashubi, some of the contained pebbles of granite being over ¼ metre long. This sandstone also occurs on the pass between Hedemia and Abuzag, the altitude of which by aneroid was 696 metres above sea-level. At the head of the valley running from this point, the cañon-structure is strikingly displayed, these light-coloured beds forming almost vertical battlemented walls

(about 45 metres high), overhanging a sandy plateau, which is again cut into by deep, narrow, winding ravines, themselves carried down deeply into the underlying granite. Under Abuzag the terraces appear horizontal, but there is some local variation in dip, probably due to slipping. These upper beds contain a few large boulders, (one about 60 cm. by 43 cm.), but usually the detrital material does not exceed 6 mm. The larger boulders in places give rise to well-developed but small earth-pillars. Further north, in the upper part of Wadi Awaja, the sandrock becomes more and more filled with detrital matter, coarser and finer layers alternating in the side-valleys. On crossing the northern pass of Wadi Awaja, the calcareous sandstones disappear, their place being taken by typical boulder terraces of the ordinary type, forming walls in places over 15 metres high and close to the pass containing boulders up to 60 cm. in diameter, but increasing in size towards the lower part of the valley.

The origin of this remarkable deposit is undoubtedly difficult to explain, the natural view that it is of marine derivation not being absolutely confirmed by the discovery of any marine organisms. Nevertheless the results obtained by Walther are in favour of this hypothesis, which would demand a differential movement of no less than 700 metres in the southern end of the peninsula during comparatively recent times, a result which, however startling, is in accordance with other evidence from neighbouring regions.

D.—Gravels cemented by Calcite.

While in the Dahab peninsula the surface is formed by low ridges (2 metres) of interstratified small boulders and coarse gravels, a second terrace lies against the foothills in which the fragments are larger (over 30 cm. in diameter), and not only such as would come from the neighbouring coarse granite region, but more often syenite and types of felsite such as occur in the Ferani range. These gravels which abut against the granite are of the usual pebble-gravel type referred to in A. In contrast to the above, there occur in the lower part of Wadi Nasb, and especially close to its junction with Wadi Abuksheib, certain terraces resting on Nubian sandstone and granite, containing boulders of syenite, biotite-gneiss, felsite, and red granite (often over one metre in diameter) *cemented together by crystalline calcite* in the form of well-developed scalenohedral crystals. This curious occurrence has only been noted in this neighbourhood, and higher up the valley a little west of the point at which Wadi Ra'ib joins Nasb, so that at present it remains a peculiarly local development.

b.—Travertine and conglomerate cemented by Travertine.

The question as to the origin of the cementing calcite in this and the previous case admits of at least three possible solutions, two of which would regard the chemical changes as still proceeding, while the third refers the action to effects which are no longer in operation. The second view depends upon the fact that the felspathic constituents of diabases are known to readily undergo decomposition resulting in the formation of calcite, and these being everywhere abundant as dykes in the granite, etc., might easily give rise to soluble bicarbonate which subsequently is re-deposited as travertine. In support of this hypothesis might be mentioned the apparently close connection of the calcareous deposits and the present valleys, though it would require an analysis of the torrent waters to show whether carbonate of lime is in sufficient quantity to have the above-mentioned result. The third hypothesis assumes that the depression above-mentioned affected the Sinai Peninsula to the same extent, in which case nearly the whole of the southern valleys would be submerged, as well as the lower part of Wadi Nasb and its tributaries, and calcareous deposits might then be laid down, but the comparative rarity of these beds renders it inadvisable to bring in an assumption involving wide-spread physical changes, where a simpler explanation is available.

Summary.

It will thus be seen that the gravels everywhere bear evidence of movements of elevation, erosion now in all cases exceeding deposition, while if the oolitic calcareous sandstones are of marine origin they involve a differential movement of at least 700 metres in Pleistocene times. It has further been shown that these gravels must themselves be of late origin, as they overlie coral reefs containing Pleistocene shells.

CHAPTER VIII.

CORAL-REEFS.

At the commencement of a paper * above-mentioned, occurs the following statement:—"The shore-boundary rich in corals is entirely wanting in the Gulf of Akaba. Only to the east of Ras Mohammed small fringing reefs (Schirmriffe) are found against the steep slopes of the cliffs and more extended reefs of younger Tertiary age are

* Walther, *loc. cit.*, p. 40.

also to be observed. In the main gulf there are also small coral aggregations at the mouth of Wadi Nasb and Wadi Ghazaleh. Immediately beyond the shore depths of 60 to 150 fathoms have been noted, while at the exit of the Tiran Straits, bottom was only touched at 594 fathoms. Therefore the Gulf of Akaba presents itself as a deep rift, bounded by steep slopes, and poor in reefs." The same impression for the southern end is left by a study of Moresby's Admiralty chart, which was probably followed by Prof. Walther, as the latter does not himself appear to have visited the shores of Akaba. As a result of the present expedition, the views expressed above must be finally abandoned, Skill having now mapped practically continuous reef from Dahab to Ras Mohammed, wherever it was possible to observe its outlines from the shore. It forms an almost continuous fringe which renders approach to the coast dangerous for even small boats, except at a few localities, such as Dahab, Nebk, and Sherm.

The Fringing reef and Lower Coral series.

The fringing reef is in reality one of the most conspicuous features of the gulf, extending from the shore as a white, narrow, usually submarine ledge, its outer border being marked by a long line of surf, beyond which the water is of intense dark-blue colour, due to its great depths. Closely associated with it, but at a higher level, is a second reef, which to the north forms isolated terraces up to 25 metres high, standing only a little way back from the water's edge. The former is naturally the one which attracts the attention of the zoologist, but the latter is also characterised by a very rich and varied fauna.

Lower Coral series.

The Gulf of Akaba was first visited at the northern end of the narrow plain which bounds the southern hills of the peninsula to the east, a cliff 15 metres high rising somewhat abruptly out of the gravel plateau at Ras Atantur. The hard beds at the top of this ridge are of coral limestone, the Astræan corals composing it being very abundant and large, (*Orbicella Forskaliana*, E. and H.), while associated with them are round pieces of granite, schists, and other igneous fragments. Above the main reef is a thick bed of large pebbles, mainly igneous, while below it are soft, salt-bearing marls, in one place containing a band of broken oysters (see Miocene). At the foot of the main cliff is a raised beach, composed of large shells, among which *Tridacna* is

especially abundant, associated with *Conus*, *Natica*, and many other genera. Just above sea-level is a more modern beach containing much coral, sea-urchins, the red organ-pipe coral *Tubipora*, while red masses of *Polytrema* coat the larger shells. Further south the summit of the main ridge consisted of raised beach containing casts of an *Oliva* and bivalves, while in the Astræan coral limestone *Laganum depressum* is present. In the closely consolidated limestone below, many large spines and fragments of sea-urchins, the former of the compressed Echinometrid type (*Heterocentrotus*), are associated with large *Tridacna* and casts of Gasteropods, the whole being covered by a coarse pebble gravel, and being of Pleistocene age.

The sea-shore was again visited at Nebk, where the coral-reef forms a flat limestone fringe almost on the same level as the shore itself and completely covered at high water, no outstanding ridges being noted between Nebk and Ras Atantur.

A short distance to the south rise low terraces at first separated from the sea by a beach and small marshes, while close to the shore there is also a hard compact sandy limestone, in which bivalves and large Gastropoda are imbedded. The low cliff formed by these terraces contains *Heterocentrotus* spines, *Tridacna*, *Venus reticulata*, L., *Cardium leucostoma*, Bom., *Spondylus aculeatus*. Chem., *Cerithium Ruppelli*, Phil., *Pirenella mammilata*, (Risso), *Conus catus*, var., *nigropunctatus*, G. B. Sow., and *Conus textilis* L. var. *vicarius*, Lam., and *Ostrea*, and is capped by the well-marked Pleistocene Astræan corals, these beds being evidently identical with the *Laganum*-bearing strata of Ras Atantur. A traverse to the hills prevented a continuous study of the coral-reefs, but they were again met with north of Aad Bay. Here a calcareous sandstone nearly 2 metres thick and generally dipping 2·5° N. E., forms the base of the series, a very hackly stratum constituting the summit of the terrace consisting essentially of Astræan corals, innumerable casts of Gastropoda, and bivalves mingled with detrital material, especially quartz fragments. Near the sea the reef consists of massive limestones containing grains of quartz and felspar, blocks of coral, casts of shells, and perfect examples of *Cyprœa*; while higher up are small blocks of granite and basic rock, about 2 metres in diameter. About 6 metres above sea-level *Tridacna*, sea-urchin spines, *Cyprœa*, and the Astræan corals of single type bound together are abundant and good *Lithodomus* borings are noticeable. These, closely associated with numerous Nullipores, form a second shelf. The terraces increase in importance and height as Aad Bay is approached, corals abounding in the small bay, and being very varied in character. Turning slightly

inland, the nature of the strata is seen to undergo a change, the lower ones being full of large oysters, *Pecten*, *Laganum depressum*, a young *Clypeaster* and *Echinus verruculatus*, associated with these being deep-brown and greenish beds containing salt similar to those noted at the base of the coral reef in Atantur. In places these are capped with a pebble bed of granite, diorite, etc.

The best sections are those seen immediately north of Sherm, and from these the following typical succession may be given, beginning from above :—

1. Cavernous calcareous limestone (Older Coral Reef) which has undergone dolomitic alteration, containing *Orbicella Forskaliana*, *Goniastræa favus*, Forsk., and three other Astræan types, *Cœloria arabica*, *Anadara*, large gasteropod casts, Nullipores. Thickness one metre.

2. Coral and Millepore limestone, in places forming a small vertical cliff, and to the east changing into a compact white chalk, in which are casts of the large bivalve *Venus reticulata*. Four metres.

3. Oyster and Pecten beds, full of oysters, *Pecten Vasselli*, *Laganum depressum*, and the small *Echinus verruculatus*. These beds undoubtedly correspond to the *Pecten Vasselli* beds from kil. 152 of the Suez Canal, which yielded Fourtau *Echinus verruculatus*, *Tetrodiscus auritus*, *Temnopleurus toreumaticus* and *Laganum depressum*, var. *sinaiticum*. *

4. Brown and greenish salty marls, possibly Miocene.

These are *apparently* succeeded by

5. Nullipore rock.

6. Limestone with large ornate *Venus*, *Cypræa*, *Tridacna* and a large *Trochus*.

7. Limestone rich in Gasteropoda, etc., including the striped *Strombus*, *Conus*, *Dentalium*, sea-urchin spines (*Heterocentrotus*), *Goniastræa*, and several species of *Fungia*.

8. This limestone is separated from the sea-shore by two beaches, the higher consisting of larger spineless specimens of *Echinometra lucunter* associated with *Haliotis*, while the lower consists of small varieties of the same sea-urchin still covered with their spines.

Nos. 1 to 4 include the Older Coral Reef series, the latter being the oldest member and No. 1 the youngest.

Nos. 5 to 7 form a second terrace, and compose the Younger Coral Reef series, No. 7 being younger than No. 1, but older than 6 and 7. Finally, No. 8 is quite recent.

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* See Fourtau, "Sur la faune échinitique du golfe de Suez." Comptes rendus, May 4, 1903.

CORAL REEF, ETC., AT SHERM BAY.

These double terraces are broken across by the broad bay of Wadi Aad, whose shore consists of raised beach crowded with shells of the volutiform *Strombus*, large *Pteroceras*, *Terebellum*, *Cerithium*, and many bivalves including *Arca*, *Cucullæa*, etc. On the other side of the valley, the double terraces having again been crossed, a small hill in the plain some distance from the sea was ascended, and was found to consist of a semi-crystalline hackly limestone in which the only fossils present were a few traces of corals (in which the calyces are separated by cœnenchyma) and a *Pecten*. Its height is 52 metres above the second terrace and its beds are dipping 4° S. E. This was the first case met with in Sinai of tilted coral reefs such as will be described later, the fauna in which is usually so badly preserved as to render the determination of their geological position difficult.

Returning to the sea-coast the terraces are again crossed, these uniting toward Sherm to form a perfectly flat plateau composed of the *Cœloria* beds of the Upper Coral Reef, and having sandy granitic beds mixed with ochreous sands below, while at the base are ferruginous strata containing much salt. This reef contains large oysters, *Spondylus*, the ornamented *Venus* and *Orbicella*, associated with Barnacles, Millepores, and many badly-preserved corals. It can here be seen that the reef is unconformable to, and independent of, the underlying sand-rock, the latter dipping 4°. While in Sherm Bay the manganiferous gravels form the main portion of the cliff, the southern bay of Merza El Awaja is bordered by raised beach with shells similar to those of Aad, but as the rocky coast at the foot of Gebel Zafara is approached, the shells become of large size, the shore being strewn with *Tridacna*, *Fasciolaria* and *Pteroceras*. In Gebel Zafara the relations of the various beds are by no means easy to determine. This hill consists of sand-rock mainly derived from granite and strata of sandy lime-stone in which no fossils have been observed, while the rounded quartz-pebbles in them recall those of the Nubian sandstone. They dip 21° south-west, and at the southern base of the hill the coarse granitic sand-rock is overlaid by a very hackly limestone, from its cavernous structure being evidently an old coral reef. Immediately to the south commences typical "Upper Coral Reef," underlying which is gypseous sandrock and marl, the latter in places containing the large Miocene oysters subsequently described. Above these gypseous beds rounded pebbles and boulders of red granite and limestone make their appearance where coral-reef is absent, and become very coarse on the summits of some of the ridges. In the reefs themselves are casts of a dwarfed volutiform *Strombus*.

These low terraces extended between Zafara and Hedemia Bay, the shore of the latter being again crowded with a rich variety of tropical shells. South of the bay they are rich in shells including Astræan corals associated with small *Fungia* (including *F. dentigera, F. scruposa,* and *F. placunaria,* Gregory), *Conus* and *Cyprœa*. The upper part of the series is composed of *Coeloria* limestone. Inland rise several yellow hills (Gebel Asfar), which on examination are seen to be formed of a very cavernous limestone. As noted from the summit of one of these, the distribution of the sedimentary hills with regard to the granite and the variable direction of the dip suggests that these limestones have been faulted down by north-south and east-west faults, the "Upper Coral Limestone" having been subsequently laid horizontally on their flank. The dip of the cavernous limestone where first observed was 15° south-west, then swinging round to 30° east (see map). On leaving this point, a second coral hill to the south was visited, the beds in which were tilted at an angle of 60°, being very crystalline, but still containing recognizable oysters and casts of *Pecten*. The crushed appearance of the beds close to the felsite region, and the presence of quartz-rock, points to the existence of a strong fault at this locality.

Returning to Hedemia Bay and following the coastline, our road lay among the coral reef series, which forms a thin covering to sandy beds with red ferruginous bands and lines of pebbles dipping 4° south-east, while in the small valleys a flaggy rock of granitic material also appears at the base, having the same dip.

The district between Hedemia and Ras Mohammed Bays is entirely occupied by the two coral terraces; the Lower Coral Limestone is crowded with shells, some species being locally more developed than others. Thus at one spot the rock contains flattened sea-urchin spines and the striped *Strombus* in abundance - elsewhere the latter is associated with *Conus*, these being perfect below, but only in the form of casts near the summit of the lower terrace. The highest point of the latter is almost entirely occupied by a *Pectunculus* bed, above it being over 10 metres of an unfossiliferous hackly limestone, probably part of the Upper Coral Reef.

The lower reef north of Ras Mohammed Bay is characterised by the large size of the Gasteropoda present, especially *Terebra* and *Murex*; while *Tridacna*, the striped *Pectunculus*, *Dentalium*, and many other molluscs, are associated with them. At the head of the bay is a hill consisting of very wind-swept crystalline limestone, furrowed into long ridges, the impact of the pebbly particles having apparently produced crystallisation. In it casts of *Turbo*, *Conus*, *Cyprœa* and

other bivalves were still recognizable, associated with small *Fungia* and a single-pored coral which has undergone much alteration, internal casts of its calyx being alone present.

The fringing reef was traced all round the outside margin of the land, near Wadi Ghazlani being two metres below the surface; on the northern side of Ras Mohammed it is almost on shore level, and though apparently a flat limestone surface, is in reality filled with small pools and depressions, in which living Ophiurids find a congenial home, sometimes associated with beautiful crimson *Stylasters*. There are also near the shore a number of small outgrowths from the main coral floor, which curiously simulate atoll structure. Near the cape itself the coast rises, and from the summit of the cliff, the reef is seen to form a narrow fringe over which the surf is constantly breaking, while several large blue-coloured fishes were disporting themselves in the foam. Here the reef resembles an open network structure and seems to be merely a thin limestone film attached to the sides of the main rock and overhanging the abyss of deep water.

The raised beaches and Lower Coral limestone are well developed on the further flanks of the low hilly backbone which runs down the centre of the Ras Mohammed peninsula, on its northern side being a beach, chiefly composed of small *Cerithia* accompanied by minute *Nerita* and bivalves. Nearer the sea the coast becomes sandy, and further to the south-east the Lower Coral limestone forms a low ledge. In the small rocky bays is a modern shell-beach composed of the larger shells, such as *Tridacna* and *Pteroceras*. On the southern side extends a plain which is cut off from an island by a long arm of the sea; this is entirely composed of the striped *Strombus* beds, also crowded with *Pectunculus* and *Oliva*, while on the eastern side of the axis *Oliva*, *Murex ternispina* and other large forms characterise a higher beach, these being replaced towards the sea by the small *Cerithium*, which is present on the flat shore in great abundance. The central axis of Ras Mohammed is composed of a limestone ridge, which at its extreme point rises to 90 metres above the sea, and whose strata dip at an average angle of 4° south-west. These are formed of hard limestones and cast-beds, containing casts of corals, *Conus* (?), *Spondylus* (?), strata of oolitic nature also being present. Further south is a Nullipore limestone also containing gasteropod casts, and only in a lower ridge does the true Upper Coral Limestone make its appearance. As Walther has remarked, the preservation of the fossils is such in the oldest reef as to render the determination of the age of the latter very difficult. The prevalence of the north-east wind is well marked by the

deep grooves running parallel to that direction in the coral limestone, which is also remarkably broken up by fissures running mainly in an east-and-west direction.

Having thus dealt with such details as are necessary, special stress may be laid on the following general points :—

The coral reefs of the Gulf of Akaba show the following distribution : south of Aad Bay and Sherm there are conspicuous tilted coral hills, and two horizontal terraces representing Pleistocene reefs of different ages. Going north, between Nebk and Aad Bay, the two latter are alone represented, the tilted beds being absent. Finally, north of Nebk, only the Lower Terrace or Younger Coral reef and the recent fringing reefs are observed, there being no trace of raised coral beds high on the sides of the hills such as have been noted on the Red Sea coast. In other words, *the Older Reefs are only present at the southern end of the Gulf of Akaba.*

Coral Reefs formed in a region of elevation. From what has been said above, it is obvious that only one conclusion can be arrived at, viz., *that the coral reefs of the whole of this region have been formed during a movement of elevation, the oldest one being at the same time the highest, while the upper terrace is composed of beds which are older than those forming the lower terrace.* This elevation is directly proved from the present height of the coral reef to be at least 200 metres in amount, and the question arises, is it still being continued? For the Gulf of Akaba, the answer is perhaps a slight negative, the chief grounds for this conclusion being the discovery made by Walther, that a reef, probably dead from its striking white colour, exists under the present submarine living one, suggesting a local depression of about 6 metres, and the same idea occurred to me as an explanation of the fact that so many inlets from the gulf are only intrusions of the sea up the mouth of the valleys.

Thus Ghaslani, Sherm, Aad, and Nasb bays are all of this nature. The only other alternative would be that the material brought down by rains from the hills had had an unfavourable effect on the growth of the reefs, but against this theory many objections can be urged. *It therefore appears probable that a small local depression* (at present amounting to 6 metres according to Walther) *is taking place in the Gulf of Akaba*, the latter differing in this respect from surrounding regions.

It will now be of general interest to take up the five questions which Walther set himself, and see how far the Gulf of Akaba leads us to agree with or differ from his conclusions.

1. To what thickness may coral reefs attain? In this respect our

agreement with Professor Walther is absolute, viz., that *a coral reef does not attain any great thickness.* Thus to the north of Sherm a bed mainly composed of corals just exceeds 1 metre in thickness, and if the underlying limestones, *Pecten* beds, etc., be taken into account, 6 metres is the maximum noted. Presumably Walther has included these beds also when he gives the thickness of the younger reef at Ras Mohammed as 9 metres, and the older at about 7 metres, while the recent reef does not exceed 3 metres. The greatest thickness of raised limestone observed on the gulf is 54 metres, yet an examination of the component rocks will show that in all these beds true coral reefs are of comparatively rare occurrence, strata composed of millepores, calcareous algae, and broken fragments of sea-urchins, mixed with innumerable gasteropoda, being more conspicuous elements.

2. What is the basis of a coral reef? On this point our results differ to a certain extent, and especially in one particular to be referred to later. The upraised reefs give good opportunities in many cases for a close study of the base on which rests the limestone of the coral series, and it is seen that the latter varies very widely at different localities. Thus at Dahab it consists of granite gravels which near the junction are full of large boulders of the igneous rocks, while at Atantur only soft, salty marls are visible beneath the coral limestone. From Dahab to Atantur no base rock has been observed, but the reef projects directly from the hills composed of gneisses and hornblende-granite, immediately outside which the sea sinks to great depths, so that it is probable that the coral has grown directly on the detrital materials derived from the neighbouring mountains. Immediately north of Sherm, a junction is again beautifully displayed, the coral reef resting unconformably and horizontally on the underlying sandrock (probably Nubian sandstone) which here dips at four degrees, while elsewhere it overlies gypseous sandrock and marl. Again, near Hedemia Bay, our field notes read: "The road taken lay among the coral-reef series which forms a thin covering to sandy beds with red ferruginous bands and lines of pebbles dipping four degrees south-east, while in the small valleys a flaggy rock of granitic materials also appears at the base, having the same dip." Walther, after a careful discussion of the relations of the base to the coral reef (*loc. cit.* pp. 496, 498), answers the above questions as follows: "The fossil, and probably also the living coral reefs of the Sinai Peninsula are based on the outcrops (Schichten-kopfen) of compact *sedimentary* (the italics are ours) rock, they are wanting on the softer and more crumbly coast-

rocks of the Sinai peninsula." The discussion and conclusion both suggest that the igneous rocks are of little use as bases for reef formation. but if this be the right interpretation of Walther's view, strong exception must be taken here to such a limitation, which would render it impossible to account for the existence of the fringing reef bordering the hills south of Dahab. Indeed elsewhere, on the western side of the Red Sea and on the eastern border of Gebel Esh, where coral-reef is tilted over 20° all along the sides of the igneous hills, the limestone is only separated from the underlying granite by a thin granitic conglomerate, and near Qosseir there is scarcely any detrital material between the diabases and the coral bed plastered against them. Instead, therefore, of having any limitation, we conclude that in general, *the deposition of a coral reef is practically independent of the nature of the rock forming its base.* Our own experience now includes red granite, diabase, sandrock, and marls amongst the basal members, with gneiss and hornblende-granite as highly probable.

3. What rôle does detrital filling material play in the living reefs? Practically there is nothing to add to Walther's statements. He very justly points out the easily breakable character of the madrepores and the importance of the calcareous algae, such as *Lithothamnium* and *Lithophyllum*, in binding together the broken fragments or forming a crust over a sandy floor, on which basis a coral reef can be built up. It may here merely be further stated that attention is also called by the above writer to the importance of crabs in breaking up the organic remains, producing the fine calcareous sand which fills the cavities between the dying coral-stems, and in addition may be noted the abundance of the red encrusting foraminifer *Polytrema*, the fragments on the shores of the gulf being in places completely overgrown by this bright-coloured organism.

4. What alterations do the reef-sediments undergo when they finally rise out of the water?

The effects of change are only too quickly visible, the brilliant-coloured living reef being replaced nearer the shore by the dead-white surface so familiar to all students of coral deposits. As the coral limestones are examined the observer cannot fail to be struck with the absence of many forms, which on the sea-shore itself seem to be the principal members of the fauna. In vain will traces of crabs be sought for, though on the beach they occur by thousands, while the beautiful *Phyllacanthus*, the large *Heterocentrotus*, and many other fine sea-urchins, are only represented by spines in varying degrees of

preservation. Though Ophiurids fill every pool, they leave no record behind them, and if it were not for the abundance of Mollusca and the corals, but little would be left to recall the life and movement of the tropical marine fauna.

No doubt this disappearance has in large measure to do with the *instability* of the *aragonite* composing the skeletons of many of the above-mentioned animals, while in addition, in the higher parts of the reef, the progressive formation of casts from shells of *Strombus*, etc., can be watched in all its various stages. But this is not the only change to which a coral reef is subject, and the upper terrace has lost its whiteness and taken on a dusty grey appearance, which is indicative of the further chemical alteration, viz., *the passage from limestone to dolomite by the increase in magnesia.*

This change is too well known to require further pressing here, and Walther's analyses show how far it has advanced in some of the reefs. As a result the coral structure has become practically obliterated, and in the older reefs, where the correct identification of the fossil contents is of first importance, the collector finds only unidentifiable casts, or at most the last traces of calices and septa.

5. The final question—What alteration in form and extension of reefs has taken place in the course of geological history?—has been answered as far as possible previously, but it may be here repeated, that apart from the tilted limestones whose age still remains uncertain, the two horizontal raised reefs do not appear to be older than the Pleistocene, north of Nebk the Pleistocene terraces, but little above sea-level, being alone present.

CHAPTER IX.

MIOCENE ROCKS.

(Originally published in Geol. Mag. June, 1904, pp. 250-252.)

The study of Egyptian geology during the last few years has thrown a flood of light on the former extension of the Mediterranean southward in Miocene times. Th. Fuchs,* in examining the rich collections from the Cairo-Suez desert and the oasis of Siwa, recognized that the

* Th. Fuchs, "Beiträge zur Kenntnis der Miocenfauna, etc.," in Zittel, "Erforschung der Libyschen Wüste," p. 36.

Miocene strata had a close resemblance to those of the Vienna Basin, and corresponded to the Grunder beds at the base of the second Mediterranean stage, or the lower portion of the Middle Miocene. Later L.H. Mitchell *, when studying the neighbourhood of Ras Jemsa and Gebel Zeit in 1887, obtained a number of large oysters, which Meyer-Eymar recognized as *Ostrea crassissima* and *Ostrea gigantea*, and which were regarded as proving the existence of strata of Upper Miocene age along the western border of the Suez Gulf. From these results Blanckenhorn † concluded that the Gulf of Suez must have been a Mediterranean bay in Miocene times, and further noted (Zeitsch. Deutsch. Geol. Gesell., Band liii, 1901, p. 79) that characteristic Miocene Pectens, viz. *Pecten Sub-Malvinæ*, occurred in the collection made by Barron at Abu Sha'ar. He further formed the opinion that all the marine Miocene strata in Egypt were of the age assigned to them by Fuchs (see also Barron and Hume, "Miocene Rocks in Eastern Desert," Memoir of Egypt. Geol. Surv., 1902, pp. 159-165).

Strata of similar age were first found in the Sinai Peninsula by Bauerman in 1868 ("Note on a Geological Reconnaissance in Arabia Petræa," Quart. Journ. Geol. Soc., xxv, pp. 24 and 37), and were subsequently examined by Rothpletz ("Stratigraphisches von der Sinai-Halbinsel," N. Jahrb. für Min., 1893, i, p. 103) and Blanckenhorn (Zeitsch. Deutsch. Geol. Gesell., Bd. liii, 1, 1901, p. 75), the latter tracing them from Wadi Gharandel to the mouth of Wadi Tayiba. When examining the southern end of Eastern Sinai, the present writer was surprised to find beds of large oysters in the terraces a few kilometres south of Sherm, at the foot of a marked transverse range, the Gebel Zafara, these being especially marked in Wadi Khoraiya. On comparing these with the oysters from the Miocene west of the Suez Gulf, there seemed little doubt that the species were identical, but to fully establish the point the specimens were submitted to Dr. Blanckenhorn, who has recognized the oysters of Wadi Khoraiya as *Ostrea Virleti*, Desh., and typical *Ostrea gingensis*, var. *setensis*, Blanck., while *Ostrea Virleti* was further recorded from a limestone above brown sands between Nebk and Sherm. The latter was evidently derived from the older Miocene series, but is now associated with Pleistocene fossils.

In a paper on the geology of Eastern Sinai (International Geol.

* L. H. MITCHELL : "Ras Gemsah and Gebel Zeit : Report on their Geology and Petroleum" ; Cairo, 1887.

† M. BLANCKENHORN, "Die Structurlinien Syriens und des Rothen Meeres" : Richthofen Festschrift, Berlin, 1893.

Congress, Paris, 1901) the writer called special attention to the existence of certain highly-tilted beds occurring at the southern end of the peninsula, in most cases standing well back from the sea and having undergone extreme alteration. South of Gebel Zafara these are well developed, forming a series of yellow hills close to the junction of the igneous rocks, and rising nearly 200 metres above the sea. Here the beds have been tilted to an extraordinary extent, in some cases dipping from 30° to 60° E., and being apparently connected with a longitudinal fault of importance. In the paper above-mentioned it was further pointed out that their appearance recalled the altered coral reefs of this region, and that they still contained oysters and casts of *Pecten*, but their age was not then definitely stated. The identification of the oysters of Khoraiya leaves little doubt, however, that these beds also are of Miocene age, and we therefore arrive at the conclusion that the *Older Tilted Reefs at the southern end of the Gulf of Akaba are Miocene in age* and agree with those on the western side of the Gulf of Suez. Dr. Blanckenhorn has made some observations in sending the specimens which it may be of interest to quote here. "It is to be assumed that *Lithodomus* (*Botula*) *cinnamomea*, *Gastrochæna Retzi*, oysters of the *crassissima-gingensis* group, *Lucina* sp. aff. *tigrina*, and corals like *Cyphastræa chalcidicum*, etc., persisted from Miocene to Pleistocene times in the Erythræan region in a salt 'Binnensee' situated somewhere in the deepest part of the Gulf of Suez. In the Upper Pliocene there was the second invasion of Mediterranean forms into the Erythræan region. At this point there came in *Pecten varius*, *Pecten benedictus*, *Cerithium conicum*, *Ostrea cucullata* and *O. plicatula*, *Arca lactea*, etc. Possibly in the neighbourhood of Sinai there may be a place which still contains remains of this more continental transition period between the Middle Miocene (Helvetian) and the Upper Pliocene. Might the N°. 4798 [this is the above-mentioned *Ostrea gingensis*, var. *setensis*, of Wadi Khoraiya] be included here?"

Having seen the deposits from both the Eastern Desert of Egypt and Eastern Sinai, it seems to me impossible to separate the two, and if the former are Helvetian the latter must also be of the same age, so that the conclusion is forced on us that the Gulf of Akaba (at least in part) was already occupied by the sea at this early period. The question thus opened is a wide one, and whatever its solution demands far-reaching hyphotheses. Did the Miocene sea extend over the whole peninsula, and are these but faulted relics of this Mediterranean advance, or was the present configuration of this district so far outlined that two arms of the sea already bounded the Sinai Peninsula, though connected

with the Mediterranean instead of the Red Sea, as at the present day ? In the central Sinai ranges no traces of such strata have been met with in the fault-valleys, and the final answer will probably only be obtained when the plateau of El Tih has been more closely examined. The other alternative appears to be that fault or rift action had begun at a far earlier date than is usualiy assumed.

In any case it can now be definitely stated that *Miocene* strata of well-marked character are also present in the Gulf of Akaba area, and Barron * has found *Pecten*, *Ostrea*, and *Heterostegina* beds of the same age to be present in the whole sedimentary area of the west of Sinai.

CHAPTER X.

CRETACEOUS LIMESTONES AND NUBIAN SANDSTONE.

As previously stated, the older sedimentary strata only appear in the northern part of the area studied by the Survey (see Plate XXII) where in the neighbourhood of Ain el Hudera, they form an important element in the structure of the country. Viewed in broad outline, the Cretaceous limestones have given rise to the rolling upland plateau of Gebel Gunna, which terminates in a steep escarpment facing southward ; but between it and the igneous ranges is the Nubian sandstone region, where isolated masses of white sandrock, now cut by vertical furrows to their very base, rise as isolated buttresses over 100 metres high, bounded on all sides by vertical walls. Between these extend broad, smooth-surfaced plains, in general sloping gently northward, due to a hard ferruginous bed overlying variously-coloured ferruginous sandstones, which themselves have been deposited on a planed-down surface of granite. These relations have been complicated by the faulting to which the region has been subject. Owing to the existence of the Ra'ib rift, these strata are separated from the sea by the long range of granite which extends from Noweiba to Dahab, and similarly granite hills rise from among them, or tongue into them, in a bewildering manner when first observed, though a closer study renders it possible to trace the various faults and folds which have caused the complexity. To the same cause are due the outliers of Um Raiyig,

* The details will appear in the Survey Report on the western side of Sinai Peninsula.

Wadi Ra'ib, etc., remnants of the Cretaceous plateau which have been preserved in the fissures, while the same beds on the mountain summits above have long since disappeared.

1.—Cretaceous Limestones.

The detailed section of these strata is obtainable with great accuracy on the slopes of Gebel Gunna, and the following thicknesses were determined by aneroid measurements. The succession is as follows, beginning from the summit.

	Thickness in metres.
(1) Summit of escarpment composed of ferruginous limestone of hackly character, having a well-marked oyster-bed, from which the fossils could not be obtained in recognizable form owing to the compact nature of the rock *	61.0
(2) Limestones, whose upper beds contain *Echinobrissus* and *Diplopodia variolaris*, whilst in the lower one bivalve casts are abundant	22.5
(3) Limestone with *Exogyra olisiponensis* followed by a characteristic striped series of green marls containing a typical Cenomanian fauna, viz., *Periaster oblongus* (first noted by Duncan),† *Tylostoma elatius* and *Heterodiadema libycum*	3.5
(4) Loose sandstone and marls, containing large *Exogyra olisiponensis* in abundance	14.0
(5) Forming base of hill white grits of the Nubian sandstone, the uppermost 10 metres being more compact, owing to the presence of lime ‡	200.0
	301.0

Um Raiyig.—The outlier of Gebel Um Raiyig also gives an excellent section of the fossiliferous beds, the succession being as follows:—

Summit.

(1) Bedded limestones, from which no fossils were obtained.

(2) Strata containing numerous *Tylostoma* and *Cucullæa*, a cast of a *Nautilus* having also been obtained. Thickness 18 metres.

(3) Compact limestone with large casts of *Tylostoma globosum*, in the downwash being numerous specimens of *Periaster oblongus*.† Thickness, 6 metres.

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* These strata have been much disturbed, and have a minimum dip of about 30 degrees, this being due to faults, which are prominently developed on the sides of Gebel Ghlim to the east.

† Probably the one usually classed by later writers on Sinai as *Hemiaster cubicus*. The echinoderm fauna obtained by the Survey in Sinai having been submitted to Prof. J. W. Gregory for examination, he has recognized the following new species in the collection from the Cenomanian of Jebel Gunna: *Heterodiadema bigranulatum*, n. sp., *Acanthechinopsis Humei*, n. sp., *Micropedina bipatellis*, n. sp., *Coptosoma gunnehensis*, n. sp. In the Um Raiyig collection he notes *Holectypus cenomanensis*, Guer., *Micropedina bipatellis*, n. sp., *Nucleolites daglensis*, (Gauth.) and *N. gibbosa* (P. and G.). See *Gregory, Geol. Mag.*, No. 503. Dec. V., vol. III, n° 5, pp. 216-227.

‡ With the exception of the faulted strata in N°. 1, the dip throughout the series was practically nil.

(4) Green, closely-banded marls consisting almost entirely of *Ostrea Rouvillei*.

(5) White sandrock of the Nubian series.

These Cretaceous beds as a whole form a syncline, dipping north at the southern end, while to the north the dip is reversed.

Gebel Ejjibi. In Gebel Ejjibi the succession is very similar, the *Ostrea Rouvillei*, *Tylostoma* and *Periaster* beds being all represented. These strata appear to be repetitional, and the strike of the beds is a marked curve, with a westward dip predominating. Blocks derived from a bed almost entirely composed of *Ostrea Rouvillei* were abundant on the slopes of the hill, associated with large Exogyrae (*E. olisiponensis*) and many fragments of ferruginous sandstone.

The thicknesses of the strata are as follows:—

Summit.

1. Compact limestones	over	33	metres
2. Oolitic and compact limestones	„	7	„
3. Compact limestone and marls	„	23	„
4. *Tylostoma*, *Periaster* and *Cucculæa* beds	„	12	„
5. Red, more sandy bed	„	1	„
6. *Tylostoma* and *Periaster* bed	„	6	„
7. Beds of more marly and gypseous nature with 1 metre band of casts of *Exogyræ*	„	5	„
8. Brown-red sandy bed	„	1	„
9. White friable sandstone			

In bed No. 1., at 11 metres above its base, is a bed of small shells and sea-urchin spines, while nearer the summit traces of mollusca are numerous, but not sufficiently well preserved for identification.

A fourth occurrence in a hill north of Gebel Um Raiyig is very similar in its character, the faulting having brought the fossiliferous Cretaceous strata into direct contact with the massive bedded white Nubian sands. At the base of this hill are the brown *Tylostoma* limestones, above these being an *Exogyra* bed with many sea-urchins, which is succeeded in its turn by an *Ostrea Rouvillei* layer.

Separated from the preceding by a bivalve-cast limestone is a soft green marl weathering red, and full of small *Echinobrissus* and *Strombus*, (E. cf. *angustior*, Gauth., determined by M. Fourtau*), accompanied

* His remarks on these specimens are as follows :

Echinobrissus near *angustior*, Gauthier, from the Upper Cenomanian of Bou Saada. This species is also present in the Upper Cenomanian of Tunis. It would be more prudent to regard this as a local variety *sinaica* than as a new species.

The presence of the *Cyphosoma* is also significant as no true Cenomanian *Cyphosoma* has as yet been recorded from Algeria and Tunis.

by a few specimens of an ornamental regular echinid. (*Cyphosoma* aff. *majus*. Coq.) The whole series is crowned by flaggy and brown compact limestones, the latter containing casts of vertebræ. (In the field-notes possible signs of worm-tracks and rain-prints were also mentioned).

Mr. Bullen-Newton has recently identified a number of the Cretaceous forms above-mentioned, and from Um Raiyig records *Strombus*, allied to *Arnaudi*, Péron; *Tylostoma globosum*, Sharpe; *Exogyra olisiponensis*, Sharpe; *Exogyra africana*, Lam.; *Gryphæa vesiculosa*, J. de C. Sow.; *Diplopodia variolaris*, Brong.; *Linthia oblonga*, d'Orb.; *Hemiaster scutiger*, Forbes; *Hemiaster Heberti*, Coq. and *Goniopygus Menardi*, Agassiz. From Gebel Gunna he has recognised *Nerinæa mamillæ*, Fraas, of which only one specimen was obtained by the writer; *Tylostoma elatius*, Coq; *Ostrea*, probably a new species, allied to *lignitarum*, Coq. and *Exogyra olisiponensis*. He further notes that these specimens appear to belong entirely to the upper or younger division of the Cenomanian stage, as some of the species pass up into Turonian rocks, especially in Portugal.* The Sinai beds are obviously closely related to those in Egypt which were originally classed by Professor Zittel under the name "Africano-Syrian" series, and which have now been shown by many writers to extend from Baharia through Gebel Gallala to Sinai itself.

The Eastern Sinai beds differ in some respects from the strata of the same age to the west, more especially in the absence of two characteristic Exogyræ, *E. flabellata* and *E. suborbiculata*, Lmk., which are still found in great abundance in Western Sinai, but appear to be markedly absent in the beds now under consideration.

M. Fourtau has recently † also dealt with the Cretaceous subdivisions and fauna. He holds that both in Egypt and Sinai the Cenomanian begins below with chloritic marls containing *Hemiaster cubicus*, Desor., and *Ostrea olisiponensis*, Sharpe, in abundance, the beds being of Uraconian age and corresponding to the Bellusian of M.Choffat. Then follow limestones and marly beds with *Ostrea africana*. The upper part is a siliceous limestone with *Heterodiadema libycum*, Cott., *Hemiaster pseudo-Fourneli*, P. et G., and *Ostrea suborbiculata*, Lmk. The resemblance to the series in Algeria is very striking. He considers that the term "Africano-Syrian" is too limited, the Cenomanian strata of similar character ranging more widely than the name indicates and therefore recommends the use of the term "faciès Mesogéen."

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* (See Paul Choffat : Syst. Crétacique de Portugal, 1900).

† (Bull. Inst. Egyptien, April. 1903. Étude de la Fauna Crétacique d'Egypte, pp. 232-347).

It is evident that the higher fossiliferous beds of East Sinai are practically at the junction of the Turonian and Cenomanian series, the coming in of *Cyphosoma*, the abundance of sea-urchins of the *Periaster* type, and the character of the *Tylostoma* species all pointing in the same direction. Among the latter a very inflated species has been obtained, which in every respect resembles the *Globiconcha ponderosa* recorded by Coquand, and described by him * as occurring in the Carentonian (Upper Cenomanian) of Tenoukla.

If these beds are uppermost Cenomanian, the main limestone of the escarpment is of Turonian or even later date.

Nubian Sandstone.

The Nubian sandstone unfortunately is not as yet of palaeontological or economic interest, the well-known Carboniferous limestone of Wadi Nasb thinning out eastward before entering our region, and there is therefore no proof that any of the Ain el Hudera sandstone is Carboniferous. Indeed throughout the whole of the 200 metres of sands and sandstone, no organic remains of any kind were noted. The sandstone itself falls lithologically into two series (1) the white or variously-coloured sand-rock, and (2) ferruginous sandstones, the latter forming the base of the series. These relations were well seen when examining the various sections observed in the peninsula. The Nubian sandstone was first met with at the junction of Wadis Nasb and Shelala, where it has been let down in the Nasb-Shelala rift. It here consists at the base of variegated banded sandstone, very gritty in places, and containing well-marked purple, pink, and yellowish-white bands, one yellow ferruginous layer being especially conspicuous. The whole is dipping 12° north-east. Above these ferruginous beds is a thick mass of sand-rock, which near the base contains a number of small quartz-pebbles up to 12·5 mill. in diameter.

Owing to the compact nature of this rock, it overhangs the underlying strata in consequence of differential weathering. The unconformable junction of the whole series with the igneous rocks is well-marked, the sandstone having been laid on a planed-down granite surface penetrated by a diorite dyke. The great mass of sandstone which separates Wadis Shelala from Wadi Rahab is over 100 metres (358 ft.) thick, and dips 16° 5 east.

Owing to the absence of identifiable fossils, it is impossible to say with absolute certainty that Nubian sandstone occurs south of this

* (Geol. Province Constantine p. 178).

point, but judging by lithological characteristics, its existence in Southern Sinai is highly probable. This is notably the case under the marked terraces existing near the mouth of Wadi Kyd, a yellow sandrock being here present, which contains rounded pebbles similar to those of Wadi Shelala. North of Sherm, the coral reef rests unconformably and horizontally on the underlying sandrock, which there dips four degrees, while near Hedemia Bay, the coral-reef series overlies sandy beds with red ferruginous bands and lines of pebbles dipping four degrees south-east, and in the small valleys a flaggy rock composed of materials derived from granite also appears at the base, having the same dip. These rocks extend to the southern end of the peninsula, where a low hill is in large part composed of southward-dipping sands and hard ferruginous sandstone with yellow ochre, the whole being capped by hard crystalline limestone.

These sandy beds would have been unhesitatingly referred to the Nubian sandstone, were it not that strata of very similar character alternate with sandy limestones in the slopes of Gebel Zafara, and limestones are never associated with typical Nubian sandstone in Eastern Sinai. The probable explanation of the difficulty appears to be that the Nubian strata are developed in the south, but have been in part denuded and re-assorted to form new strata of Miocene age, the older sandstone having been preserved owing to faulting along the line of the Gulf of Akaba.

Wadi Ra'ib, etc.

As in Wadi Shelala, so also in Wadis Ra'ib and Dahab, the Nubian sandstone is found in the valley far south of its main outcrop. This is especially the case at the junction of Wadis Dahab (Nasb) and Abuksheib, where a thick mass of Nubian sandstone has been faulted down. Resting directly on a sloping platform of granite and diabase, it consists at the base of a grauwacké, followed above by purple sandrock and grits. Isolated blocks of the same nature are scattered up the valley, one of these in its centre being purple-coloured, and consisting of a very friable ferruginous sandrock, passing rapidly into a perfectly white grit. In both the weathering is tabular or cubical in character.

Nubian Sandstone on Granite Plateau.

The interest of this occurrence has already been emphasized in connection with rift-action, the Nubian sandstone being also present on the summit of the plateau which rises 300 to 500 metres above Wadi

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Ra'ib, &c. Here it occurs as isolated knobs or outliers, being well-banded, with red and yellow-coloured stripes ; the layers are often beautifully curved, and the rock itself is extremely friable. The granite has been planed to a flat surface, where the sandstone rests upon it. The most prominent outlier is Gebel Rai'emshi, where the sandstone has been laid down on the granite. At the base the beds almost entirely consist of irregular quartz grains from 3 to 6 mill. diameter, whilst higher up the rock becomes more compact, finally passing into a white sandgrit. Further north, in the Berga plain, these fine-grained white grits contain beds of hard ferruginous sandstone, which give rise to the long flat slopes of Al Fara. There is probably a fault at the west end of this plain, the Nubian beds being lower than the granite ; their dip is on the average 2 to 3 degrees northward, but in places rises to 8 degrees, possibly due to slipping.

It would be wearisome to describe every section exposed in detail, it will suffice to note that along the main outcrop of these beds the series consists at the base of bright-red and purple sandstone, weathering to a uniform yellow-brown tint, and practically made up of sandgrains.

In places bands of yellow colour are intercalated, and in addition there is a complex tiger-skin structure, due to the alternation of purple and white sandstone stripes. Above these purple and red beds are outliers of white grit, forming bold masses with vertical walls, and often fretted with a rectangular pattern of a very regular kind.

Cannon-ball concretions are also often present in the white grits, these being more especially prominent near the summit of Gebel Amutamir.

Origin of the Nubian Sandstone.

The origin of this widely-spread sandstone formation has been hitherto wrapped in mystery, owing to the uniformity of its lithological conditions and absence of organic remains. Extending in Egyptian territory from its uttermost western confines in Dakhla Oasis to the extreme eastern boundary in Sinai, it cannot be dismissed as a mere local occurrence, and it is therefore not surprising to find so earnest a student as Walther stating that "a careful study of the so-called Nubian sandstone has led me to the conviction, that these sandstone beds are an aeolian dune-formation and point to the existence of palaeozoic and mesozoic deserts in North Africa." * This view has been also

* (Reprint from Verhandl. Ges. f. Erdkunde zu Berlin, 1888, N° 6, p. 10).

pressed by Fourtau.* In neither case, however, is the matter discussed in detail, and there are certain reasons which lead the present writer to a somewhat different conclusion as regards the origin of the sandstone itself.

In the first place it must be remembered that the sandstone is always laid down on a planed surface of the older rocks, whereas in the present desert region wherever igneous rocks are exposed they give rise to precipitous crags or rolling hills. One force only could have produced so uniform a level, and that is the invading waters of an advancing ocean. It would appear rather that the Nubian sandstone is the African equivalent of the terrigenous deposits, such as greensand, gault, etc., which in Europe mark the passage from continental to oceanic conditions. That the sandstone† is more probably of marine origin is also shown by the frequent presence of coarse conglomerates at its base, the extreme rounding of the quartz pebbles, and the rare presence of marine shells in it, as shown by Dr. Ball at Aswan,‡ and the unbroken passage to marls containing marine faunas of definite age. The remains of fossil trees and leaves, and the existence of oolitic iron ore near Wady Halfa, on the other hand show that the continent was not far distant.

It may be freely admitted that the continent itself was probably under desert conditions. The brilliant colouring of the sands below and the fine-grained nature of those above certainly suggest the existence of vast dunes on the sea-border, and the absence of any traces of land-life all point in the same direction. It may therefore be concluded that the Nubian sandstone of East Sinai represents the shallow marine terrigenous deposits laid down during the depression of a continent, taking place during the various stages of the Upper Cretaceous, the formation extending, so far as known at present, from the Cenomanian to the Senonian.

CHAPTER XI.

IGNEOUS ROCKS OF EASTERN SINAI.

The complicated and intricate character of the Sinai peninsula is fully reflected in the igneous rocks composing it, these in a limited

* Comptes-Rendus, Nov. 10, 1902.

† As the Carboniferous sandstone, etc., is not at present known in East Sinai, the question of its origin is not included in the above discussion.

‡ The Upper Cretaceous species *Inoceramus Cripsii*,, according to Dr. Blanckenhorn.

space illustrating many of the most difficult problems with which petrographers have to deal. The nature of their distribution and the precipitous forms of the hills in which the best exposures occur, render a study of the relations less easy than in the districts previously examined by the writer; on the other hand the general arrangement appears to be the same on both sides of the Red Sea.

On entering the mountain region at Wadi Isla, the rock forming both sides of the ravine proved to be essentially a *biotite-gneiss*, some of the foliation bands being darker and more micaceous than the main mass; it appears to agree in all its main characteristics with the low-country or gneissose granite previously described in the report on the Eastern Desert (p. 85 and 117), which is also developed on a large scale in the cataract districts of the Nile. On ascending Gebels Hormadjan and Eth Themnin, which border Wadi Isla, their summits were found to be composed of *coarse granite*, the biotite-gneiss being restricted to the lower slopes, indeed the whole of the Theman range appears to be of the former type, the quartz crystals in some instances being more than 2·5 mm. in length. A similar change from biotite-gneiss and hornblende-granite to coarse red granite is observed when the valley itself is ascended, a granite with large quartz, red felspar, and chloritized biotite taking their place. The hornblende-granite essentially contains colourless quartz, white felspar and dark-green hornblende, titanite being also frequently present according to Fraas. The rock is therefore similar to the granites of Aswan and the island of Philæ, as well as to that of Gebel Gharib in the Red Sea hills *.

Triple Rock Division in Sinai hills.

The succession noted in Wadi Isla is repeated throughout the greater portion of the Sinai ranges, the three rock-types above-mentioned being so frequently associated together that there seems to be some intimate connection between them. The granitoid gneiss and hornblende-granite appear to be the fundamental rocks of the central axis of the peninsula, the red granite being subsequent to these, and often shewing structures characteristic of intrusive bosses. Various localities may be taken as type-examples, to illustrate the relations of these holocrystalline acid and more foliated members to each other, any prominent variations in their structure or relation ships being also noted.

As already remarked, the striking feature in the neighbourhood of Wadi Isla is the fact that the summits of the ranges consist of the quartz-felspar granite, the biotite-gneiss occurring at the base; on the other hand, in ascending the valley no line could be drawn between the gneiss and granite, but at a certain point (St. VI. of the field-sheets kept in the Survey offices) the grey speckled gneissose biotite-granite commences to be replaced by the coarse red variety, the latter in many places containing but little quartz, or else quartz and felspar combined in about equal proportions. The red granite is often broken up by joints into large rectangular blocks, and is much veined by dykes of red granite and quartz. Further up the valley, the rock becomes more complex, broad basic bands alternating with fine-grained types of the quartz-felspar granite. Near the mouth of Wadi Um Arag there is a particularly fine example of one of the black dykes traversed by red granite veins.

The whole of the region drained by Wadis Eth Thebt and Tarfa appears to be essentially composed of the biotite-gneiss* which at the head of Wadi Tarfa *overlies and is intruded into by a red, very quartzose granite*, poor in mica, which also forms the main mass of Fersh Sheikh El Arab.

Distribution of igneous rocks.

Owing to the many minor variations in the rock-structures, it was impossible to obtain a clear idea of the relations of the main constituents whilst in the valleys, and it was only on ascending the commanding summit of Abu Mesud that an opinion could be formed as to the distribution of the igneous rocks in the neighbourhood. Here three types of country are clearly outlined. 1. A light-coloured granite region traversed by innumerable dykes forms most of the district immediately to the north of Wadi Nasb and at the head of Rahabeh, while south of Nasb N° 2, the darker green-tinted biotite-gneiss predominates. Though the difference is very distinctly marked when seen from above, it would be difficult to trace the boundaries of these two divisions from the valleys themselves, as a hornblende syenite,† which closely resembles the gneiss, is also present in the first-named

* The gneissose structure is in many cases so little marked that in the field-notes it is generally described as a biotite-granite.

† The hornblendic holocrystalline member is variable in mineral composition, and in the following remarks is described as hornblende-granite or syenite according as quartz be present or absent.

area, in which otherwise the predominant member is granite. The biotite-gneiss of the second division is in its turn penetrated by the bright-coloured red granite N° 3, which is widely distributed, and forms several distinct mountain groups, the base of the Abu Mesud plateau, and the high peak of Nakhara.

Graphic granite.

On leaving the plain of Rahabeh, Wadi Nasb is for a short distance in close proximity to the boundary of the above-mentioned regions 1 and 2, the first-named consisting as previously stated of the decomposing light biotite-granite traversed by parallel dykes, and the second being darker in colour, more complex in structure, and richer in hornblende. One of the tributaries, Wadi Hezaima, entering Wadi Nasb from the north, drains a district which is mainly composed of a coarse decomposing micaceous granite, in places *finely graphic*. This rock is continued in the prominent ranges of Abuksheib, Hezaima, and Beidha, giving the latter the very light colour to which it owes its name (Arab. the white mountain). A very noticeable feature is the weathering of this rock, deep hollows or caves having been formed in the boulders*. This may be due to several causes, especially the wearing away of the easily cleaved biotite, and the loosening of the coarse grains of quartz by the breaking down of the more readily decomposable felspars in the neighbourhood of the holes thus produced. The ranges of hills enclosed in the angle between Wadis Nasb, Um Ghirat, and Senned, appear to be composed of this biotite-granite, as a rule weathering in rounded masses, but the rock forming the summit of Um Beda is of a somewhat drusy character.

When Wadi Um Rachal enters Nasb, the geological conditions are much more complex, purple and green decomposing schists being intercalated in and alternating with an almost graphic granite, which as the valley is ascended is succeeded by hornblende-syenite, biotite-granite, and finally a banded granulite. The schists (having a sp. gr. of 2.72) are in reality a contact-alteration, being composed of quartz, hornblende, and magnetite, and are probably altered grits (N° 3453)†. The purple variety is on the other hand composed of quartz, felspar, and chlorite

* This feature in granite has of late aroused attention, and its origin requires special consideration and study. See Bonney, "Some eroded Rocks in Corsica" (Geol. Mag. N. S. Dec. V. Vol. I. pp. 388-392, Aug. 1904), and Baron, "Rock Cavities in Granite of Madagascar," (Geol. Mag. Dec. V. Vol. II. pp. 17-21 Jan. 1905). Obviously the character is geographically widespread.

† A number in brackets thus ( ) indicates the number of the specimen in the Cairo Geological Museum.

with irregularly distributed brownish decomposition products, and numerous highly refracting zircon-like minerals. Its sp. gr. is much lower than the preceding, being only 2·57, but it also has all the characters of a metamorphosed grit. (N° 4814).

Speaking generally, the three main divisions already recognized in Isla seem to sweep in broad bands from west to east across the country, the coarse granite lying to the north, the hornblende-granite or syenite separating it from the biotite-gneiss which spreads over the southern portion of the peninsula. At the Gates of Nasb the crossing of the Um Raiyig-Shellala rift breaks the continuity, the triple division also being obscured by the vast number of dykes which seam the older rocks in every direction.

The presence of the Madsus schistose district also for a time obscures the relations of the underlying holocrystalline rocks, but these were again studied in the upper part of Kyd and its main tributaries. Here immediately west of the schist district, Gebel Gazala consists of coarse granite with scattered mica, much chloritized, while a little further to the south the rock is a very quartzose biotite-granite. In Wadi Um Gerat, a short distance from the junction of the granite and schists, gneisses are finely developed, occurring, however, in bands only a few metres thick, alternating with a deep-green or black hornblende schist. This highly foliated structure seems to be purely local, the gneissose character as a rule being somewhat obscure. The explanation which suggests itself is that broad bands of granite have penetrated between schistose beds, and the two have subsequently been involved in mountain-forming changes while the granite was in a plastic condition, or have been drawn out under the dynamometamorphic pressures. The acid and more basic members alternate, interdigitate or interfoliate in the most complex manner. In microscopic section the gneiss is mainly composed of quartz drawn out along the foliation lines, some felspars, and films of biotite, the specific gravity varying from 2·63 to 2·70. The basic member, on the other hand, is a hornblende-plagioclase rock, with a sp. gr. of 3·01.

Further to the west, the normal biotite-gneiss makes its appearance, this rock apparently overlying more schistose members. It is often rich in mica, is extremely friable, and contains quartz veins, which have been much folded and fractured. The fundamental rock is more difficult to determine in this district, many variations being noticeable. Gebel Geraui is mainly composed of schists and gneisses, which are sometimes granitic and at other times dioritic lithologically, the whole being traversed by thick bands of quartz-felsite, between which the

schistose beds often stand vertically, it being frequently impossible to assign a special foliation-dip to them.

The main mass of hills fronting the central range (Um Taibekh, Sahasia, and the Genaui-Mazeeh range) is distinctly composed of the biotite-gneiss with numerous dykes, while the central range itself seems to be the coarsely granitic rock, there being no evidence of a type rich in hornblende lying between the two. A series of cross-sections taken across the country show that the rock variations are divisible into certain broad categories related to one another.

On the latitude of Sabbagh the central range is still the coarse granite of Eth Thebt, while the foothills to the east (Um Ekhlis) are in the main the biotite-gneiss, these in their turn being succeeded by low hills, entirely composed of highly quartzose granite, which occupy all the remaining space between the gneiss hills and the sea. The true relations of these rocks is well shown in Wadi Yahamed, where the dark-blue biotite-gneiss is intruded into by the orange-red highly quartzose low-country granite. Still further south, on the latitude of Um Adowi, the central range itself undergoes a marked change, the coarse, red granite no longer occupying the central axis, but being replaced by a *hornblende-granite*, (with little quartz and much acicular hornblende) which forms both the mountain masses of Ethnarbi and Um Adowi, as well as most of the higher peaks of the central range in their neighbourhood, e. g. Aad, Sahara, etc. There is a still more interesting development in the spur of Haimar and Gebel Aad, the normal hornblende being in part replaced by the deep blue-green soda variety, riebeckite. This mineral was formerly mistaken for tourmaline by the writer, the long black acicular crystals recalling the latter in hand specimens, but Professor Bonney, who has kindly examined many of the Sinai micro-sections, has recognized its true character. Further to the east, the hornblende-granite is replaced by biotite-granite, in which a gneissose structure is locally developed, but is not usually well-marked. Finally, the hills bounding the coast plain are essentially composed of a coarse red granite, but with little mica or hornblende.

In the side-valleys of Wadi Awaja, the relations of the first two rock-members to each other are more clearly displayed, the maze of hills being composed in a somewhat bewildering manner of three types of acid rock. 1, biotite-gneiss, or granite with gneissose structure, whose components are of small size. 2, a medium-grained hornblende-granite, grey in colour, and 3, a red granite which does not appear to differ from No. 2 except in colour. The difficulty of identification is increased owing to the ready decomposition of the rocks, No. 2 being

especially prominent in this respect. Here the gneiss is apparently the oldest, and has been intruded into by the coarser and more quartzose members.

The sequence of these rocks near the Kyd-Madsus schist-region being given in Pl. XXI it will be unnecessary to enter into a detailed description of them. As a type of the whole, the rock-structures as displayed along the coast of the Gulf of Akaba may be now considered. Viewed from the camp at the mouth of Wadi Gnai el Atshan, the hills which rise steeply from the shore are observed to be very differently tinted, and an examination shows that these again fall into three distinct types: 1, hills composed of the light highly-quartzose granite, similar to that of the Gnai range; 2, a darker-coloured range, formed by a well-marked rock, showing distinct massive banding, this in the main being a biotite-gneiss, but with it being closely connected; 3, a hornblende-syenite or diorite similar to that found on the other side of the watershed. Passing southward, a sharp change takes place, distinct red and grey finely-banded gneisses forming the southern foothills.

The No. 1 granite gives rise to abrupt peaks and difficult summits near its junction with No. 2, while dolerite dykes penetrating it produce deep grooves separated by precipitous slopes.

Proceeding southward the hornblendic gneissose syenites are the main components of the cliffs as far as Wadi Waira, these being in places penetrated by basic and fine-grained felsite dykes, while the gneisses (much folded and contorted) appear to form a band bending inwards from the shore-line.

In Wadi Sajerat these become very fine-grained and smooth-surfaced, having an apparent eastward dip of about 30°.

Generalizing for the whole district, it may be stated that all the hills facing the sea appear to be composed of the non-quartzose hornblende-biotite syenite with large sphene, but whether ascending Wadis Mowila, Sajerat, or Um Ekhmoil, the result was the same, viz. this rock being succeeded by distinct grey or red gneisses. The latter series is often brightly coloured, the succession of green and red bands in it forcibly recalling a felsite and dolerite alternation, while the intermixture of a hornblende-biotite-gneiss similar to the syenite suggests that the whole gneissose series is the latter plus its dykes, very much crushed. It must, however, be admitted that the gneiss band is very well defined.

This triple division, which is constantly repeated, is evidently not an accident, but must be connected with important differences in the igneous rocks themselves, these being of regional value. In considering the question of their origin, attention may be called to a further striking

feature in the Sinai peninsula, giving rise to scenic characters of the first magnitude, as already shown it the section on Topography.

A study of the rocks commonly classed as metamorphic has led to their division into two groups, the one derived from "rocks of consolidation," or igneous rocks, largely characterized by their crystalline nature and coarseness of grain; the other schistose in character, derived from sedimentary and detrital formations. Both the groups are represented in Sinai, and illustrate the relations of a heated magma when brought into contact with a more ancient volcanic and sedimentary series. The result of this intrusion on the heated magma itself may first be considered.

Igneo-Metamorphic Rocks.

Varied theories have been suggested to account for the structure of the granites and gneisses included under the above term, and it will be easy to shew that several of these may be at once rejected, so far as Sinai is concerned. That the gneisses, etc., are not part of the primitive floor is proved by the fact that where they meet the superincumbent schists the latter have undergone distinct contact metamorphic changes.

Weinschenk (Congrès Géologique International Paris, 1900, Vol. 1, p. 340, *Sur le Dynamométamorphisme et la Piézocrystallisation*) has given an explanation which seems best to satisfy all the conditions observed, though there are some details which do not appear to be perfectly clear from his theory. "All study of this question tends to show definite relation between mountain-folding and the appearance of granitic masses. By the external pressure exercised during folding, the fluid magma rose from the depths, and was injected between strata of different geological horizons, while colossal movements and dislocations accompanied the phenomena of intrusion. The intensity of stress was not altogether abolished by the injection of the liquid magma, and the latter was consolidated under the mountain-forming pressures which still continued. The first minerals of consolidation are the dark minerals, hornblende and mica, the mica being the first-formed in the liquid mass. At this moment, the orogenic pressures acted on the peripheral zone of the magma, orientating the minerals normally to the pressure. In the heart of the viscous mass this faculty of orientation has been replaced by an internal stress acting in all directions. This is the explanation of a peripheral schistose zone shading into a granitic kernel."

Mr. Teall, in his Presidential address to the Geological Society, May, 1902, has put the matter very tersely when he says: "Thermo-metamorphism will not account for the facts, neither will dynamic metamorphism; but if we combine the two ideas, and recognize the fact that thermodynamic metamorphism may be associated with the intrusion of molten mineral matter and the formation of mixed rocks, we find ourselves in possession of a powerful intellectual weapon wherewith to attack many problems connected with this puzzling group."

This method is the one which must be used to explain the Sinai problem, the explanation here offered being as follows:—Dynamic movements (folding, etc.,) permitted of the intrusion of an igneous magma, which in places surrounded, cut off, and partly melted down portions of the overlying sedimentary mass (See Um Gerat gneisses, p. 66) while in other areas the latter only displays the more usual contact phenomena. Consolidation commenced with the formation of hornblende and biotite, the rocks near the junction being normally syenites or diorites, while the pressures have been sufficient to give the magma a slightly gneissose aspect. This outer peripheral zone was already somewhat resistant when a second pressure of greater power was transmitted to the interior portion of the solidifying magma, producing the gneisses of the interior zone. *

Newer red Granite and Igneous Dykes.

While this theory accounts for the granitoid gneiss and the hornblende granite, the ancient sedimentary and igneometamorphic complex appears to have been invaded at a later date by a very acid magma, and by a series of dykes which have been contemporaneous with the red granite masses or of later date. The red granite, which consists of quartz and dark-red felspar in equal proportions, other constituents being rare, plays an important part in determining the more salient features of the country. Its most extensive development is in the central range, where rising through the gneisses and ancient granites, it forms the precipitous crags of Serbal and Um Shomer, the long knife-edges of Rimhan and Theman, the bold summits of Eth Thebt and Sabbagh, finally disappearing in the low country near Wadi Budr.*

* Its extension south of Sabbagh was determined through specimens brought by Herr Guyot from Wadi Budr. The watershed must have originally followed this granite ridge, and still follows it to-day. (See p. 17).

A similar ridge culminates in the peak of Derawi, and several of the smaller ranges above Nasb are also of the same character.

In some cases the red granite has risen in gigantic bosses, giving rise to steep mountains with rounded summits, exemplified by Gebel el Deir opposite Gebel Musa, or again forms much of the low country near Wadi Nasb, etc., though nearer Sherm the granite in the foothills is rich in porphyritic felspars, and probably represents the more acid portion of the rock series described in the previous section. To the north of Wadi Nasb the areas occupied by the gneisses and red granites are sharply marked off from one another, differing in colour, and to a certain extent in surface features; thus the true granite country is usually more rugged and has a distinct and characteristic red shade. Quartz and orthoclase are the characteristic minerals, but in some localities muscovite mica is a common constituent, especially where the granite borders the schist region at Gebel Naba. The presence of graphic structure has already been mentioned.

Igneous Dykes.

One of the most striking features in Sinai is the remarkable banding produced by variously coloured dykes, which seam the mountains and cross the highest peaks, preserving a perfect parallelism to each other, which persists over many kilometres. Even before Wadi Isla is entered, the small ridges which cluster at the foot of the higher mountains are observed to owe their origin to dykes mainly trending in a north-north-east and south-south-west direction, and in the high ranges of Shiddok and Emlaha, the red and dark bands pass over the main crest. These veins practically extend throughout the whole igneous region over many kilometres without any perceptible break in their continuity, and by their superior hardness determine the directions of many ranges. When composed of basic rocks, they often produce gullies, which not infrequently form the only road by which some of the steeper scarps can be ascended.

These dykes are of almost every petrographical variety, from the coarse quartz-felsites and fine-grained felsites, which are more commonly found in the granite regions, to the dark dolerites and spheroidal diabases * which in the metamorphic areas are sometimes so crowded as completely to mask the schistose rocks enclosed between them. They are clearly the youngest members of the igneous series, as every other

* One of these rocks in Wadi Jendeli consisted of fine-grained augite, magnetite, and chlorite.

FORMATION OF DYKE SUMMIT, GEBEL KATHERINA.

type of rock has been penetrated by them, but as has been previously remarked, none of them have been noted passing into the Nubian sandstone, which rests upon a plane cutting them off abruptly. In Eastern Sinai, at any rate, all the dykes appear to be pre-Cenomanian, and judging from the neighbouring regions, probably pre-Carboniferous also.*

Duplicate system of dykes.

While the general trend of the main system of dykes is north north-east and south south-west there is frequently a second system, generally roughly at right angles, which occasionally shows marked differences though these are not sufficiently constant to establish any general rule. In the slopes of Abuksheib, above Wadi Nash, a north-west to south-east trending group consists of basic dykes which have shifted the acid and basic members of the principal series, and are consequently of younger age. Two may also cross each other, giving rise to X-shaped forms such as are developed in Wadi Letih, or to an interlacing mass of dark veins, there being a beautiful example of this class in the hills near Dahab.

Thickness of dyke.—The dykes vary considerably in thickness, sometimes being only a few centimetres wide, while more commonly they vary from the ten-metre bands of Isla and Beidha to the huge green dyke, 100 metres broad, which runs steeply up the granite slope opposite Gebel Jeraimda, near Dahab.

Among the rocks in the hills west of Dahab a marked dyke of satiny lustre with sp. gr. 2·62, which extends from Gebel Moghtut to Jeraimdeh, is a *porphyrite* having an angular intergrowth of red felspar still showing parallel cleavages, and fibrous chlorite derived from hornblende. Another of these rocks of sp. gr. 2·57 is closely related to a *Bostonite*, but is more coarsely crystalline, and with a chloritically altered ferromagnesian silicate between the lath-shaped felspars, hornblende also being present.

While the above remarks illustrate the main rule with regard to dyke occurrence, exceptional conditions have been observed. One of these occur in Wadi Isla, where some of the black doleritic dykes have

* The above remarks only hold good for the dykes in Eastern Sinai, in the west the fine dyke in Wadi Tayiba clearly shows that intrusions have taken place at late dates into the Nubian sandstone and younger beds, while many such have been noted by the writer in the Nubian sandstone between Dongola and Halfa.

been pinched out, leaving fragments enclosed in the gneiss. This character taken by itself might suggest that the gneiss was younger than the dolerite, but it probably owes its origin to changes produced in the gneiss during the intrusion of the dolerite. It has indeed, been shown that the heat of the intrusive mass is sufficient to melt the neighbouring rock, differential changes being produced which give rise to apparently contradictory results.* Near the mouth of Wadi Um Arag, there is on the other hand, a very fine example of a black dolerite traversed by red granite veins, showing that the acid rock was in this case of distinctly later date.

Viewed from the summit of Tellat el Gimal, the dykes are seen to vary in their direction of trend, those to the north-east of the peak having a north-west to south-east strike, while to the west they as a rule extend 10° south of west. In this connection it may also be remarked that quartz veins are of frequent occurrence, at the foot of Abu Mesud carrying hæmatite and iron ochre at the surface. The same mineral is very abundant on Gebel Tha'albi in veins and pockets, a hydrous mica also being developed is radiating fibrous masses on the surface of the rock.

Spherulitic felsites.—In his notes of specimens collected by Professor Hull, Mr. F. W. Rudler † described a spherulitic quartz-felsite from a dyke in Wadi El Araba. This rock was of a chocolate or liver-colour, in this respect differing from felsites of a similar nature which are of frequent occurrence in Eastern Sinai. On Gebel Um Zaimer the dykes are mainly syenite-felsites, quartz being comparatively inconspicuous. Among these is a handsome red rock with white porphyritic felspars and a darker variety with white orthoclase felspars of greater size, the basic material having possibly come from considerable depths and brought larger crystals with it. A banded spherulitic rock was also present near the summit, and a compound dyke, a purple porphyry forming a band on each side of a quartz-felsite. It has been a difficult question to decide whether the quartz felsites are in all cases subsequent to the red granite, dykes of this kind which penetrated the schists near Wadi el Tema apparently ending at the edge of the granite.

In general, however, the quartz-felsites are certainly younger than the main mass of the holocrystalline member. For instance, in the schist district of Um Zerig a fine-grained quartz-felsite was observed

* See for instance, Parkinson, Q. J. G. S. 1900, and Sollas. Trans. Roy. Irish Academy.

† (Professor Hull, "Survey of Western Palestine," Appendix B).

filled with rounded fragments of granite and portions of the fine-grained schists, showing that it had traversed both these rocks. On the other hand, on Gebel Um Malaga, which consists almost entirely of the coarse, easily decomposing red quartz-orthoclase granite with hornblende (usually much altered), it was observed that this rock was traversed by abundant veins of dolerite, but no quartz-felsites were visible, this observation tending to the view that these acid holo-crystalline and dyke rocks originated at the same period.

CHAPTER XII.

ON THE EVIDENCE CONCERNING CONTACT CHANGES IN A SEDIMENTARY AND VOLCANIC AREA BY THE INTRUSION OF AN IGNEOUS MAGMA.

It is evident from the above remarks that the metamorphic rocks of Sinai fall into two well-marked divisions, an *Igneous* series showing foliation, in which gneissic structure is produced in an igneous magma along the lines previously described, and a *Detrito-Metamorphic* series, including changes produced in sedimentary or volcanic materials by the action of a heated plutonic mass injected in a fluid condition. The differentiation of the detrito-metamorphic rocks is more difficult than that of the lighter igneous members, owing to their uniformly dark colour and intense penetration by basic dykes.

On entering the mountain region it was noticeable that the summits of many of the highest peaks of the peninsula were darker coloured than their granite neighbours, owing to their being capped by rocks of a different character. A subsequent examination of the peaks of Abu Mesud and Ekma showed the capping to be due to a felsite or andesite of dead black colour, containing small scattered porphyritic felspars. This rock doubtless also forms the summits of Zebir, Nakhala, and Khasib, which though not personally visited, bear the strongest resemblance to those above mentioned.

At the junction of Wadi Um Rachal, the purple and green schists already described on p. 156 were the first evidence obtained of the presence of an ancient *sedimentary* series, which further east in Gebel Ferani was represented by a fine-grained green slate penetrated by

numerous dykes of red quartz-felsites. Closely connected with this series is a remarkable conglomerate of green colour, containing numerous banded fragments of a red rhyolite, well developed at the head of Wadi Shelala, where it is overlaid by Nubian sandstone. A similar coarse conglomerate of felsitic and dark compact igneous rocks forms the summit of Gebel Ma'een, and is cemented together by a matrix having the structure of a biotite-granite.

Up to this point the observations have had reference to isolated examples, but immediately after crossing the Khlalat pass a dark schistose district was entered, here mainly composed of an alternating series of green schists and a compact banded rock, which in the field notes is described as a "kieselschiefer," and subsequently as a "hornfels." This schistose area is extensive and clearly-defined, being bounded on all sides by igneous rocks, generally syenitic in character and gneissic in structure, which not only surround, but also underlie the superincumbent schists. In the following pages the observations made during a rapid traverse of this region will be recorded, especial stress being laid on those which form a basis for wider conclusions.

The rocks of the Khlalat pass and Wadi Ethmoi are distinguished by their fine-grained nature and absence of definite characteristics, rendering it difficult at the time to determine their true relations, and in the frowning and precipitous ranges of Ethmoi and Gazala overlooking the Ethmoi valley a mica-schist associated with the "hornfels" has its foliation characters ill-defined. It was obvious that the ancient series had been subject to changes from its contact with heated igneous masses, a dolerite and a micaceous granite being recognized as intrusive.

It was not, however, till the junctions of Wadis Kyd and Ethmoi had been reached that the full significance of these rocks as *contact-phenomena* was revealed. Here the lower slopes and ridges of the Zerig hills were essentially composed of quartz-mica schists, spotted slates,* and "knotenschiefer," the knotted portions in the latter rock being well developed and drawn out. On the higher western summits of Gebel Zerig, the contact characters were subordinate to the proofs of *sedimentary* origin, the schists being occasionally replaced by paper-shales, containing many quartz pebbles which had been fractured and recemented, and also numerous quartz veins.

* A spotted slate at the summit of sp. gr. 2.71, consists in the main of quartz, biotite and tourmaline, drawn out parallel to the schistose planes, in the thick knots these materials are fine grained, with many black flakes suggesting graphite, small crystals of garnet are also present.

GRANITE RIDGE RISING THROUGH METAMORPHIC ROCKS.

Microscopic sections of these rocks, which have a sp. gr. of 2.75, show them to contain granular quartz and hornblende, their characters being those of a grit which has undergone contact alteration. A similar schist from Wadi Kyd in section proved to be a fine-grained variety, having a sp. gr. of 2.75, and consisting mainly of quartz, green fibrous hornblende, and magnetite. It was traversed by a vein of epidote.

Changes towards contact with granite.

On ascending Wadi Kyd from its junction with Wadi Ethmoi the beds are alternating "hornfels" and phyllites, but as the granite is approached, mica schists predominate, gneissose types increasing, until finally a *hornblende-schist* extends to the boundary of the granite itself, hornblende-felsite dykes at the same time increasing in importance and numbers. The granite (really a gneiss), a coarse variety with biotite, has a sharp vertical junction with the schists, which are tilted at a high angle on approaching the intrusive mass.

Southward of the Ethmoi-Kyd junction, ascending Wadi Zerig, the contact changes are of a different nature, the spotted slates, etc., apparently passing into an *andalusite-schist*, which contains large crystals of andalusite showing the characteristic pink pleochroism, and flakes of biotite mica, the remainder of the ground mass consisting of a mosaic of quartz.

Returning to the western junction of the granite and schists, the contact at first corresponds with the lower portion of the great tributary of Wadi Um Gerat, where its characters were well displayed. The schists are seen to be dipping at high angles near the margin of the granite, their schistose character being preserved up to the point of contact, and also in the numerous fragments enclosed in the granite, in none of which is there any direct evidence of contact metamorphic changes. Small sills of the acid rock extend from the main mass into the schists, but only one vein 7.5 mm. in breadth was noted, the remainder not exceeding 12.5 mm. The intruding rock at this point presents no special feature, being a coarse, very quartzose biotite-granite. Ascending Wadi Um Gerat, a short distance from the junction of the granitoid gneiss and schists, are the true gneisses (sp. gr. varying from 2.63 to 2.70) previously described on p. 157. This highly foliated structure appears to be purely local, the gneissose character otherwise being as a rule somewhat obscure.

From the southern bend of Um Gerat, the intrusive mass is represented by a biotite-granite, apparently overlying the schists, which are rich in mica, very friable, and containing quartz veins, the latter often much folded and fractured.

Following the contact southward, the junction of the normal schists and gneisses was again observed in Wadi El Tema, where the granite magma has been squeezed between the schistose strata with the result that biotite-gneisses and mica-schists are intimately mixed. Further complexities are introduced by the presence of numerous dykes such as the fine-grained red felsites trending in the usual north-east direction, the main ridge of Gebel Samra* being also composed of a highly magnetic dolerite dyke, while veins of diorite are also frequently noticeable.

The schists themselves appear to form portions of a dome, the beds varying constantly in their dip, there being a complete reversal passing southward from a strong north-east dip to one of 26 degrees south-east. In this neighbourhood the dykes of felsite are clearly seen to pass from the granitoid gneiss into the schist.

From this study of the western border it is apparent:

(1) A *biotite-granite* has been intruded into a *sedimentary series*, consisting of grits and argillaceous beds, possibly associated with volcanic ash.

(2) These sedimentary beds display varying characters according to their distance from the invading magma, those furthest removed being compact fine-grained hornfels, or spotted slates, etc., whilst nearer the junction are mica- and hornblende-schists on the one hand and andalusite-schists on the other.

(3) In Wadi El Tema the acid magma has been interfoliated with the schistose laminæ, producing a *lit-par-lit* structure, mica-schists and biotite-gneiss alternating. These have been frequently referred to under the name of mictosites.

(4) The schists have undergone disturbance, the direction and amount of dip varying greatly.

On crossing the low camel-pass which separates Wadi El Tema from Wadi Gebila, the biotite-granite and schistose constituents are seen to be intimately mixed, the former having been foliated in a striking manner, and in many places enclosing portions of the schist. The junction is soon crossed, hornfels squeezed in between dolerites and

* The summit of Samra is formed of an old felsite with quartzose matrix, and very decomposing crystals of orthoclase, with possibly plagioclase felspar as well. There is a little epidote. Sp. gr. 2.65.

mica-syenite-felsites taking the place of the mictosites. In a rapid traverse made across this district from east to west, the characteristic feature noted was the enormous development of acid and basic dykes, rendering an examination of the contact metamorphic changes difficult. On crossing the second Gebila pass to descend towards the Gulf of Akaba, the igneous rock is again met with, here being a biotite-syenite, of a deep-red colour near the junction itself, but shading into a grey variety seaward; * the sedimentaries at the base of Gebel Atshan are on the other hand of the hornfels type, towards the summit becoming very micaceous, and contain conglomerated fragments of dolerite.

On the southern side of Wadi Gebila the relations are somewhat different, the red rock near the junction being a granite very rich in quartz, but in the valley large blocks of a quartz-syenite had been observed, in which the crystals of hornblende were over 10 mm. long, and of a fibrous green variety. The more acid magma appears to be the later, as it also contains fragments of the syenitic rock where the two come in contact. The junction of the sedimentaries and red granite is of interest, the former continuing their regular dip up to the point of contact with the granite, which rises in vertical bands. Great dykes of dolerite traverse the schists giving rise to the rugged outlines of many of the mountains, while the schists themselves are so broken up that they display few hand-specimen characters, and it is doubtful whether sections would reveal their true nature. In addition the dykes themselves have become foliated in places, mica having been developed along the lines of easiest fracture.

The southern border of the schist area in Wadi Kyd is only a further illustration of the fact that a granite magma has penetrated an older sedimentary and volcanic mass, a mixture of mica-schists, granulites, and dolerites having clearly undergone differential movement, the schists being in places pinched in between the granulites, and giving rise to small overthrusts; the boundary between the granite and schistose area is at the same time very sinuous, and the dip variable, mainly southward but eastward in Wadi Tarr.

On re-entering the schist region at Wadi El Beda, the fundamental rock noted was the compact grey rock or hornfels, this being far less conspicuous than the dykes of purple andesite and dolerite which give rise to ridges separating steep boulder-strewn gullies. Many of these contained rounded fragments of granite, showing them to belong to the latest of the igneous intrusions. The rocks of a schistose character

* This rock has sp. gr. 2.73, and in section is a hornblende-granite with sphene.

here occupy a very secondary place, the compact grey Khlalat hornfels being the conspicuous member.

On the return from Ras Mohammed, the contact metamorphic area was again entered at the point where Wadi Beda joins Wadi Kyd. Here the schistose characters are completely obscured in the dark and frowning hills dominating the valley by the dolerite dykes which with their massive jointing are everywhere conspicuous. Where Wadi Madsus joins Kyd, we are in the very centre of the metamorphic region, and though the schists show considerable variation in detail, it is possible to note some broad differences, the strata being often glittering slates on the summits, while below they are darker and more micaceous, indicating closer proximity to the igneous magma. Some of the more prominent peaks (Madsus and Ethmoi, for example) are composed of semi-gneissose irregular-layered schists, which may be mictositic in their nature. The abundance of dykes* adds to the scenic complexity, the red felsites trending north-east throughout the schists, while dolerite dykes give rise to the principal precipitous ridges.

That the acid magma is never far from the surface is shown near the mouth of Wadi Amlagh, where it appears in the form of a syenite, soon again disappearing under the schists, which here overlie it in thick layers, and dip in varied directions. From one station they were seen to be dipping northward to the north, eastward to the east, and westward to the south, there being also a good deal of minor folding.

At the mouth of Wadi Sai'amin (see Pl. XXI) the contact is again clearly visible, the schists near the junction being intensely hornblendic, and massively bedded. The range of Gebel Boutroiya, which represents the intrusive element, is lithologically a syenite, but is here distinctly gneissose, and appears to have been forced in films between the schistose layers.

The following field-note written on the summit of Boutroiyeh, contains practically the main truth as to the whole district. "All the hills between Adakkar and Sai'amin appear to be of this character, viz—granite (in reality quartz-diorite) mountains simply plastered with schists, Adakkar, Um Zaimer, Hamra Er Rahab, and the present station, all seeming to form a group of mountains just released from their schistose covering. In Wadi Adakkar the schists are dipping north-north-west at their junction with the gneiss, which either meets them in a vertical plane, has been faulted against them, or thrust over and between them.

* On the side of Madsus is a felsite of sp. gr. 2.62, having a microcrystalline base in which are scattered crystals of plagioclase felspar and biotite.

The gneiss is characterized by steep and precipitous slightly rounded slopes, with a dark green tinge absent in the granite, on the other hand the schists give rise to long smooth slopes, glittering in the sunshine, and sloping according to the particular angle of dip." *

This portion of Eastern Sinai is particularly complex (see Pl. XXI) no less than five distinct members playing an important part in its structure. In the first place there are the two series whose characters and relations have just been considered, viz., the gneissose syenite and the metamorphosed sedimentaries; in the second the volcanic rocks of the Ferani range, also underlaid by the syenites. In addition there is the younger red granite of Malaga, which meets the schists in Gebel Naba, where it becomes very rich in muscovite mica. Wadi Naba is lined by schists and gneisses, the latter having sp. gr. 2·63, and possessing a granulitic structure. The component minerals are quartz, orthoclase and muscovite.

The contact-alterations were again noticed when descending Wadi Madsus, the Amlagh syenite being succeeded by bedded micaceous schists, weathering in thin flakes, plates and slabs. Though towards the west traversed by dykes of diabase and felsite, these become much more numerous to the east, red felsites and dolerites giving rise to important and precipitous crags. Ascending a station marked on the map XXVII, it was observed that the schists were mainly micaceous, in some places containing small brown-red garnets, though these in general were not perfectly formed. On the eastern side of the station the spots in the imperfectly developed schists are drawn out into long almond-shaped masses.

Of the rock specimens microscopically studied several have been obtained from this district. One of these from Gebel Akhmara (No. 3,426) had a sp. gr. of 2·91, and is mainly a quartz-mica-schist with garnets and tourmaline. The garnets show a tendency to rectangular outline, but are cracked and contain many cavities. The mica is somewhat drawn out, of green tint, with slight pleochroism and many dark spots round the inclusions, while the quartz is minute and granular. White mica is also present, and the tourmaline is in the form of small prismatic crystals of light colour, but showing strong absorption, straight extinction, and a marked transverse cleavage. On the other hand, one of the dykes forming the summit of Gebel Madsus has a sp. gr. of 2·66, the porphyritic crystals present in it being in

* In a section these schists prove to be aggregates of quartz and biotite. The rock at the base of Gebel Ethmemia had a sp. gr. of 2·77.

many cases plagioclase felspars, while the whole rock has a tendency to foliation.

The gneiss of Boudroiya has a sp. gr. of 2·68, and contains quartz, orthoclase felspar, biotite mica, sphene, hornblende, and apatite, so that lithologically it is a hornblende granite, but the quartz is not abundant. This acid character disappears further to the west, the hill masses to the west of Wadi Rahab (Um Retemi, Abu Lassaf) being much altered quartz-biotite-diorites, with a sp. gr. of 2·74. A similar rock occurring at the base of Gebel Sai'amin, with sp. gr. 2·76, also contained plagioclase felspar, interstitial quartz, and hornblende (altered in places to chlorite) the quartz-diorites thus having a wide extension at this point.

At the junction of Wadis Madsus and Melhadge the schists are again hornblendic, but in the Arabi or Ghrabi range to the east these are entirely obscured by the abundance of dykes of gabbro and red felsites, the latter often very fine-grained and without quartz. The sides of these mountains are steep, and covered with talus of readily-rolling materials which obscures their structure, while the crests are normally knife-edge ridges due to dykes.

Further north, in Gebel Um Zaireh, the base of the hill consists of dark mica-schists, having sp. gr. 2·75, and mainly composed of biotite-mica and plagioclase felspar, with a small amount of interstitial quartz. In ascending the hill, these are succeeded by glittering close-bedded micaceous schists, the highest point of the mountain being formed of a remarkably fine-grained grey rock of sp. gr. 2·68, which in the field-notes is described as possibly granulitic. This may be an extreme variation of the grits which evidently played the major part among the rocks of this region, but its origin is still open to dispute.

To the north of this hill there is an abrupt change, the dark-coloured schists being sharply differentiated from a grey massive hornblende-biotite granite, forming all the bordering low hills, which owe their lower altitude to the more rapid weathering of the granite. The granite in its turn is succeeded by the much-decomposed gneissic series already referred to (see p. 159 and Pl. XXI), the gneiss which is almost schistose and hornblendic, being thrown into small V-shaped folds. Associated with the gneissose series is a rock which, had garnet been present, could have been termed an andalusite-granulite, andalusite being a prominent constituent.

Summary.

A study of this dark schistose region reveals that it is formed of a series of ancient sedimentary grits, clays, volcanic ashes and tuffs, which have been invaded by a granitic magma, the chief minerals produced near the contact being *hornblende* and *biotite mica*. Such a change implies the former presence of a basic volcanic ash or tuff, which alone could supply the materials necessary for the formation of the ferro-magnesian silicates. The field relations, however, suggest that there is a progressive diminution of these silicates in the rocks, dependent on their distance from the contact, and point to a concentration of the basic portions of the sedimentary zone in the part which has been subjected to the highest temperatures. The hornblende as a rule occurs nearest to the igneous rock. In rare instances other products of thermal metamorphism are observed, a banded rock at the foot of Gebel Zerig being rich in *andalusite*, while *garnet* is also not an infrequent constituent. Where the pressure of the igneous flow has been parallel to the bedding of the sedimentaries, an interesting series of "mictosites," or gneisses due to interfoliation of the granite and the now schistose clayey beds, have resulted.

Other contact metamorphic areas.

Though specially developed in the above well-defined area, there is strong evidence tending to show that these sedimentaries were once far more widely distributed over the whole of Sinai. Postponing the consideration of the volcanic Ferani series for a separate section, several other schistose areas are present in the peninsula, the most notable of these occurring in the north-east angle formed by the junctions of Um Raiyig and Nasb (see Pl. XXII). On ascending Gebel Hedjan el Gimal from Wadi Um Raiyig, striped schistose rocks were observed standing at high angles and dipping eastward, enclosed between the ridges of hornblende-felsite and dolerite which give rise to the long talus slopes of the hill. These are still more conspicuously developed in the lower country to the east, where they are almost vertical or dip steeply at about 70 degrees south-east. A specimen of grey slaty nature, and sp. gr. 2·72, proved to be a contact-rock containing fine-grained quartz, hornblende and magnetite, the whole being, as in the previous case, apparently an altered grit.

The Um Rachal grits have already been mentioned, but in the southern portion of the peninsula there is also evidence of the former

presence of these ancient sedimentaries. This is the case in Wadi Moyyat El Aad, where schistose rocks, consisting of a fine-grained mass of quartz, biotite, hornblende, and abundant sphene, occur intermixed with the porphyritic grey biotite granite (in reality almost a syenite), which forms the base of Gebel Aad. In Wadi Letih, near the Gates of Letih, there is an interesting intermixture, the granite at first enclosing fragments of a finer rock, while further up the valley there is a small exposure of dark schists and red quartzose rocks dipping at 45 degrees. The presence of hornblende-granites in this neighbourhood suggests by analogy that the schistose covering was formerly of wide extension in this region.

Ferani volcanic series.

Hitherto the true sedimentary beds have in the main been considered, but in the Ferani range volcanic rocks of ancient date are closely associated with the grits above described. When issuing from the gates of Nasb, the foothills of the Ferani range were noted as being composed of an alternation of green and red rocks, the former resembling whetstones, while the latter were quartz-felsites. On ascending Gebel Ma'in the summit was found to be composed of a coarse conglomerate of felsites and dark compact igneous rocks cemented together by a matrix having the characters of a biotite-granite, and it was further observed that the felsites greatly resembled those of the porphyry ranges of Dokhan, on the eastern side of the Red Sea. At the base of the hill a similar conglomerate was in the main composed of highly banded rhyolites. The subsequent examination of the range in detail has borne out this conclusion, viz:—that great volcanic activity was associated with the deposition of these sedimentaries, the whole combination having been subsequently invaded by a granitic magma. Reversing the process by which this conclusion was arrived at from a study of the details unrolled in succession during the traverse, the details will here be considered in the light of the conclusion.

It has already been noted that the main summits of the Ferani range are composed of rocks which in hand specimens were apparently of andesitic nature. To confirm this point fragments were obtained from all the principal peaks and sections have been cut from these and examined. From this study we learn that the summit rock of Um Aleg is an ancient lava with corroded quartz and much-altered felspar in a cloudy base; that of Zaraga, on the other hand, is a re-sorted ash, made up of fragments of quartz, decomposing felspar, and pieces of

granophyre enclosed in a dusty base, the specific gravity being remarkably high, 2.69. In the lower slopes of the same hill is a devitrified rhyolite (sp. gr. 2.59) with microspherulitic and fluidal structure, an interesting point as suggesting that the acid preceded the more basic outflows. A similar rock at the foot of Abuksheib in Wadi Um Harag is also a spherulitic quartz-felsite or devitrified rhyolite.

In the lower range of Ma'in to the east of Ferani the volcanic rocks are of equal importance, the summit of Gebel Um el Wijera being composed of a devitrified fluidal lava (sp. gr. 2.65 to 2.69) with micropegmatitic base and porphyritic crystals of altered plagioclase felspar. On the other hand, the acid rock which forms the intruding member is an altered hornblende-granite, the constituent minerals being large quartz, altered felspar, hornblende, and much fibrous chlorite. The succession noted in the field-book from the base of El Wijera was as follows: The granite much traversed by diabase dykes, extends only a short distance up the hill, following on which are syenite or diorite-felsites, giving rise to a series of ridges. The peak of Um El Wijera itself consists mainly of two types of dark andesite, which also form the whole crest, the junction with the biotite-granite being at the foot of the hill. From Wadi Ma'in the succession is similar, with the exception that the granite is succeeded by a fine-grained quartz-diorite, itself intimately associated with the dykes (these including quartz felsites, hornblende-felsites and porphyrites, together with spheroidal diabases).

The following entries extracted from the field notes give the general impression formed by further examination of the ranges shown in Pl. XXI. These are in diary form.

11.4.99. "Ascended Gebel Lij, which consists mainly of felsites of the dark type, together with quartz-bearing varieties. The biotite-gneiss is present in a small basin near the summit, and also occurs in huge blocks in the boulders which fill the steep valleys on the side of the mountain. But the most curious feature is the presence of masses of coarse granite, standing like boulder heaps on the summit, and forming bold precipices on the sides. The one forming the main peak is really a very coarse quartz-felsite, in which idiomorphic orthoclase crystals are conspicuous."

12.4.99. "Wadi Um Harag traverses the felsites, most of these being fine-grained types. Gebel Um Harag and Gebel Ferani are composed to a large extent of andesites,* containing many fragments,

* In the original notes described as darker felsites.

apparently also felsitic. Through these rise quartz-felsites trending in the usual north-east direction. An interesting occurrence is the presence of what appeared to be undoubted contact schists high on the slopes of Wadi Ferani."

From the above observations it would appear that at a very early date (by resemblance with similar rocks in other countries, possibly late Archean or Early Cambrian) volcanic activity had been highly developed in Sinai; the acid lavas possibly preceding the more basic members. An acid magma subsequently invaded the whole complex, the portion nearest the contact becoming a gneissose quartz-diorite, and in some instances breaking up the felsites, etc., to such an extent that the two rocks are now closely intermixed.

Volcanic rocks are not limited to the Ferani range, being also present on the summits of many other important ranges. Abu Mesud, Nakhala, Khasib, and Ekma owe the dark colouring of their peaks to the presence of the Ferani andesite, which was also recognized in the downwash on the slopes of Gebel Katharina. In a rapid passage through Wadi Zagara under Gebel Habshi, a schist country was traversed, and there is little doubt that this mountain is like the Ferani range largely of volcanic origin.

Summary of History of Eastern Sinai.

Summarizing the observations recorded in the foregoing pages, the following are the conclusions which present themselves. The earliest chapter unrolled reveals a period of sedimentation and denudation, accompanied by intense volcanic action which spread its influence not only over Sinai, but also over wide areas in Egypt and the Sudan. Of this period no fossil remains have as yet been obtained, and indeed their presence would be surprising as the whole of this early sedimentary and volcanic region has been penetrated from beneath by masses of acid igneous rocks, granite and its allies, which have induced contact metamorphic changes in the sedimentaries, and themselves have been rendered gneissose and dioritic near the zone of contact. These in their turn have been invaded by red granites and dykes of the most varied description, the latter arranged in strikingly symmetrical lines which to-day traverse the whole country in well-marked directions.

All these complex events occurred before the deposition of the first fossiliferous limestones and sandstones of Carboniferous age on the denuded surface of the ancient continent in Western Sinai; though

these marine strata, the only records of a brief episode before the continental conditions may have once more gained the ascendant, are absent in Eastern Sinai. Of the life during the periods of the Permian, Triassic, Jurassic, and earlier Cretaceous, elsewhere marked by so varied and characteristic a fauna, there exists no trace, and only with the Upper Cretaceous (Cenomanian) does Sinai once more sink beneath the waters of that mighty ocean which spread far and wide over both hemispheres.

In this region the granite was planed down and the Nubian sandstone deposited on the plain of marine denudation, unbroken by the dykes, which though abundant in the granite, are cut off abruptly at their junction with the sedimentary rock. The sandstone, at the base brightly-coloured, ferruginous, and false-bedded, changes above into a great thickness of white, friable sands, themselves underlying marls and limestones containing a typical Upper Cenomanian fauna.

Further continuation of the history must be sought in the unstudied plateau to the north, the pages that record the Eocene and Oligocene being entirely absent in South-East Sinai itself, while only in the extreme south-east, the great oysters of Khoraiya show that the Miocene sea once spread round Ras Mohammed.

With the early Pliocene closes the period of quiet depression and deposition, or elevation and denudation, and instead we enter on a time of storm and stress, of mountain formation and gigantic fracture, which have left their mark both in chaotic confusion and far-reaching regularity. Up the broad trough thus produced advanced the invading Erythræan fauna, and the record closes with the silent witness of the coral-reefs to the gentle differential movements of to-day.

APPENDICES

APPENDICES

APPENDIX I.

METEOROLOGICAL OBSERVATIONS TAKEN IN SINAI, BY Mr. H. G. SKILL, F.R.G.S.

Total 850 readings with analyses by Dr W. F. Hume.

Observations for October, 1898.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Oct. 16	7.20 a.m.	19·7	758·5	Seaside at Tor	....
„ „	noon	30	759·3	do.	....
„ „	6.40 p.m.	25·9	757·8	do.	....
„ 17	7.15 a.m.	15·6	758·2	do.	....
„ „	noon	27·8	758·8	do.	Slight breeze.
„ „	5.20 p.m.	20·7	757·6	do.	No wind.
„ 18	6.35 a.m.	19	757·8	do.	Fine.
„ „	12.40 p.m.	28·1	759·1	do.	....
„ „	6.15 p.m.	25·5	758·3	do.	....
„ 19	6.30 a.m.	20	758·8	do.	....
„ 20	7.— a.m.	16·8	758·4	do.	....
„ „	5.— p.m.	36·6	747·3	In Qa'a plain	No wind.
„ 21	8.— a.m.	29·4	747·7	do.	Fine, still.
„ „	noon	36·9	739·2	do.	do.
„ „	2.5 p.m.	38·1	725·8	do.	do.
„ „	6.15 p.m.	29·2	728·2	do.	....
„ 22	6.30 a.m.	28	728·3	do.	Fine: no wind as yet.
„ „	3.20 p.m.	28·9	717·2	In Wadi Isla	....
„ „	4.30 p.m.	33·3	723·2	Mouth of Wadi Isla	....
„ „	6.30 p.m.	27·2	722·9	do.	....
„ „	11.— p.m.	25	722·7	do.	....
„ 23	2.— p.m.	32·8	703·6	Camp in Wadi Isla	Fine: no wind.
„ 24	7.20 a.m.	25·6	704·1	do.	....
„ „	1.20 p.m.	26·1	622·6	Summit Gebel Eth Themnin	....
„ „	7.— p.m.	23	704·2	Camp Wadi Isla	....
„ 25	7.— a.m.	25·6	703·8	do.	Fine: no wind.
„ 26	6.— p.m.	23·9	673·5	Mouth of Wadi Rimhan	Fine, still weather.
„ 27	6.— a.m.	17·8	674·2	do.	Fine, still.
„ 28	7.45 a.m.	18·9	673·5	....	....
„ „	11.25 a.m.	23·3	...	Summit, spur of Humr	No wind.
„ 29	8.— a.m.	22·4	673·3	Mouth of Wadi Rimhan	Fine: still, some cloud.
„ „	?.6 p.m.	16·7	635·2	Head of Wadi Tarfa	....
„ 30	6.— a.m.	14·4	634·3	do.	Beginning to cloud towards evening.

Observations for October, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Oct. 30	9.50 a.m.	11·5	...	Summit of Gebel Fersh Sheikh El Arab	....
„ 31	6.50 a.m.	17·2	633·7	Head of Wadi Tarfa	Heavily clouded with gusts of wind and drops of rain increasing towards night.
„ „	12.30 p.m.	25·5	633·9	do.	
„ „	5.25 p.m.	19·9	633·4	do.	

The second half of the month of October, 1898, in Sinai was in general hot and still, the maximum recorded being in the open plain of El Qa'a at 2.5 p.m., viz., 38°1,* and the minimum preceding the storm period, viz., 14°4 at 6 a.m. on the 30th. The storm of the 31st first appeared from behind Gebel Eth Thebt, heavy white clouds rolling up from the south-west. Later it divided itself into two divisions, the one advancing westward of Wadi Tarfa along the Rimhan-Um Shomer crest, and the other following the main watershed from Gebel Tarfa to Fersh Sheikh El Arab. By this division the camp itself escaped much rain, though there was a constant succession of thunder-peals and vivid lightning throughout the day, and the Arabs reported a "seil" or torrent in Wadi Wa'era to the east.

Immediately on entering the mountain gorges, the greatest care was exercised by the sheikh as to the selection of camps, there being but few places in safe positions in these deep valleys. From the above figures it will be seen that the days of maximum heat were from the 20th to 23rd, in the plain of El Qa'a and lower part of Wadi Isla.

The averages for the principal hours are :

Morning, 6 to 8 a.m. = *20° C.* (14 readings).
Maximum, 29°4 C., 8 a.m., 21st (Qa'a plain).
Minimum, 14°4 C., 6 a.m.; 30th (in mountains).

Noon, 12 to 2 p.m. = *28°8 C.* (8 readings).
Maximum, 36°9 C., noon, 21st.
Minimum, 23°3 C., 11.25 a.m., 28th (Summit of Humr).

Evening, 5 to 7 p.m. = 24°9 C. (10 readings).
Maximum, 36°6 C., 5 p.m. (Qa'a plain).
Minimum, 16°7 C. (Head of Wadi Tarfa).

From the above data it is evident that the open plain had great effect in increasing the average temperature.

* All temperatures given in this chapter are Centigrade.

Observations for November, 1898.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Nov. 1	6.50 a.m.	15	633·4	Head of Wadi Tarfa	Wind and Showers.
„ „	noon	14·4	633·9	do.	Showers.
„ „	5.25 p.m.	10·6	634·6	do.	Raining.
„ 2	6.40 a.m.	11·5	633·7	do.	Fine, still morning.
„ „	1.45 p.m.	21·8	632·6	Head of Wadi Wa'era	Fine, fleecy clouds.
„ „	5.20 p.m.	16·8	632·6	do.	....
„ 3	6.30 a.m.	11·5	631·9	do.	Still, chilly.
„ „	11.30 a.m.	17	585	Summit of Abu Mesud	....
„ „	2.— p.m.	18·2	583	do.	....
„ „	5.5 p.m.	19	652·4	Gorge of Wadi Nasb	....
„ 4	5.30 p.m.	15·3	645	do.	Thunderstorms, showery or clouded.
„ 5	6.25 a.m.	11·3	651·3	do.	Fine day, still, sunny.
„ „	1.55 p.m.	18·6	609	Summit of Gebel Beidha	....
„ „	6.— p.m.	18·5	652·0	Gorge of Wadi Nasb (mouth)	....
„ 6	6.10 a.m.	9·1	651·7	do.	Still, fine.
„ 7	4.30 p.m.	10·1	659·7	Near Nasb gorge	Fine, still, some fleecy clouds.
„ 8	5.45 p.m.	19·5	672·8	Junction Wadis Um Rachal and Nasb	Fine, still.
„ 9	6.30 a.m.	10·5	672·1	do.	At 11 a.m. hot, still.
„ „	5.— p.m.	19	670·8	do.	Some clouds.
„ 10	6.25 a.m.	11	670·8	do.	Fine, still.
„ 11	7.30 p.m.	13·4	670·7	do.	Fine, still, hot.
„ „	morning	10·5	670·5	do.	Towards 11 a.m. clouding up.
„ „	noon	19·5	669·3	Mouth of Wadi Um Beda	....
„ „	3.45 p.m.	17·7	...	Summit of Um Beda	Sky heavily clouded, no wind.
„ „	6.5 p.m.	14·4	667·1	Mouth of Wadi Um Beda	Chilly.
„ 12	6.20 a.m.	9·3	666·5	do.	....
„ „	9.20 a.m.	17·5	667·8	do.	....
„ „	2.50 p.m.	18·2	665·9	do.	Slight showers.
„ „	9.25 p.m.	11·2	666·2	do.	Intensely still night.
„ 13	7.— a.m.	12·5	666·4	do.	Clouded up towards afternoon, black clouds, showers, rain.
„ „	7.— p.m.	12·5	667	do.	Chilly.
„ 14	7.45 a.m.	13	666	do.	Some clouds, chilly.
„ „	7.— p.m.	11·3	658·5	Head of Wadi Um Rachal	Windy, chilly.
„ 15	7.— a.m.	7	658·9	do.	Small clouds.
„ „	3.— p.m.	13·9	...	Summit of Gebel Thaalbi	Chilly, little wind.
„ 16	7.— a.m.	9·2	657·6	Head of Wadi Um Rachal	Air, still, clear.
„ „	1.— p.m.	11·8	626	Summit of Gebel Adakkar	....
„ „	4.10 p.m.	11·9	657	Head of Wadi Um Rachal	Windy, chilly.
„ „	7.— p.m.	9·6	657·9	do.	Air still.
„ 17	6.— a.m.	5.5	657.5	do.	No wind, air still.

Observations for November, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Nov. 17	8.30 a.m.	9·7	657·9	Head of Wadi Um Rachal	Fine.
„ „	1.30 p.m.	11·9	...	Summit of Gebel Ashara	Fine, warm, no wind
„ „	5.50 p.m.	12·0	658·2	Head of Wadi Um Rachal	A few motionless fleecy clouds.
„ „	8.— p.m.	8·7	659	do.	....
„ 18	6.— a.m.	6·1	659·8	do.	No wind, clear.
„ „	8.— a.m.	8·7	659·8	do.	....
„ „	4.15 p.m.	16·9	694·6	North bend of Wadi Nasb, 500 metres lower than previous camp.	Air still, clear.
„ „	8.— p.m.	14·1	695·4	do.	Still, clear, fine.
„ 19	5.40 a.m.	10·5	695·9	do.	Still, fine.
„ „	8.10 a.m.	13·6	695·8	do.	Windy, north.
„ „	2.40 p.m.	11·3	...	Summit of Gebel Ma'in	Keen north wind.
„ „	7.— p.m.	15·3	695·6	North bend of Nasb	do.
„ „	9.— p.m.	13	695·9	do.	Still.
„ 20	7.— a.m.	11·6	695·5	do	Air still, fine.
„ „	5.30 p.m.	16·8	692·1	do.	North wind.
„ „	7.— p.m.	16·5	693·1	do.	Air still.
„ 21	6.— a.m.	12·8	692·5	do.	North wind.
„ „	8.19 a.m.	14·4	692·9	do.	Heavy clouds from north.
„ „	10.30 a.m.	18·9	693·5	do.	Slowly moving clouds, occasional drops of rain.
„ „	6.— p.m.	15	687·7	Wadi Rahab	Still, fine.
„ 22	6.30 a.m.	8·8	689·7	do.	Quite still.
„ „	9.— a.m.	17	690·9	do.	Fine, still.
„ „	4.— p.m.	19·3	690·6	do.	Fine, sunny.
„ 23	6.15 a.m.	13·2	690·6	do.	Fine, still.
„ „	1.— p.m.	26·5	691·3	do.	Fine.
„ „	2.20 p.m.	25·5	690·9	do.	Rather hot.
„ „	4.30 p.m.	21·8	691·2	do.	Fine, still. Magnificent weather all day.
„ „	4.50 p.m.	21·0	...	do.	do.
„ „	7.40 p.m.	17·7	691·4	do.	Still night.
„ 24	6.10 a.m.	15	686·4	Wadi Rahab	Still.
„ „	11.15 a.m.	27	...	Station in Wadi Rahab	Faint breeze.
„ „	1.45 p.m.	28	...	do.	Fine.
„ „	3.30 p.m.	23·2	...	....	....
„ „	5.15 p.m.	21·3	697·3	South end Wadi Rahab	Still, cloudless.
„ „	8.35 p.m.	17·8	697·4	do.	Air still.
„ 25	6.15 a.m.	15·3	696·7	do.	Still, fine.
„ „	1.30 p.m.	22·4	...	Summit Gebel Zaimer	Hot, still, a whitish mist has risen over lower mountains.
„ „	7.30 p.m.	19·2	696·8	South end Wadi Rahab	....
„ 26	6.35 a.m.	14·4	696·1	do.	Still, fine.

Observations for November, 1898 *(continued).*

Date	Time	Temperature Centigrade	Pressure Millimetre	LOCALITY	REMARKS
1898					
Nov. 26	9.— a.m.	22·9	...	South end Wadi Rahab	Hot, still.
„ „	1.25 p.m.	26·5	712·8	Wadi Ethmoi and Wadi Kyd	Slight wind.
„ „	3.25 p.m.	27	...	do.	Brilliantly fine, little windy.
„ „	?.6 p.m.	24·4	712·4	do.	....
„ „	8.— p.m.	22·2	712·5	do.	....
„ 27	6.45 a.m.	17	712·9	do.	Still, windy night.
„ „	2.10 p.m.	23	...	Gebel Ethmoi	Hot, still. In eveneng quite still, close.
„ 28,29	..	..	...	Wadi Ethmoi and Wadi Kyd	Fine, hot, still days.
„ 30,31	..	..	...	....	Fine, hot, still.

The month of *November* divides itself into two parts, the first half and especially the first week being very unsettled. Thus on the 1st a heavy thunderstorm broke over Wadi Tarfa, while on the 3rd and 4th there were thunderstorms in all directions, on the 3rd camp having to be moved to sloping ground, as a flood was expected. The second week was showery and chilly, but without electrical disturbances, and after the 21st the weather was continuously fine. The storms noted appeared to be coming from the south-west and were similar to the one recorded in October.

On the whole the month may be termed fine, the proportion of chilly, damp days to hot, fine ones, being: Chilly, etc., days 12. Fine, hot days 18.

The averages for the principal hours are:

Morning, 5 to 8 a.m. = *11°·3 C.* (25 readings).

(This average would have been higher had the last three days been included, but owing to the illness of the observer, these observations were omitted.)

Maximum, 17° C., 6.45 a.m., 27th (in Wadi Kyd).
Minimum, 5°·5 C., 6 a.m., 17th (on plateau at head of Wadi Um Rachal).

Noon, or Maximum day Observations, *12 to 2* approximately = 19° C. (19 readings).

Maximum, 27° C., 3.25 p.m. (Wadi Kyd) on 26th.
Minimum, 11°·8, C. 1.0 p.m., 16th (summit of Gebel Adakkar).

Evening, 5 to 7 p.m. generally = *16°·2 C.* (23 readings).

Maximum, 24°·4 C. on evening 27th (Wadi Kyd).
Minimum, 9°·6 C., 7 p.m., 16th (head of Wadi Um Rachal).

From this it will be seen that the coldest days were the 16th and 17th, the hottest the last four days of the month. There is one point of abrupt change to be noted which is directly correlated with a geographical change.

On the 18th the party was on the Sinai plateau, the morning temperature being 6°·1 C. only. In the evening the camp was in the deep rift of Wadi Nasb, and this descent was accompanied by sharp rise of temperature, 16°·9 C. being recorded in the evening, and 10°·5 C. the next morning.

The temperature-difference due to this change will be best shown by reference to the differences between the 17th and 19th.

	6 a.m.	8.30 a.m.	8 p.m.
17th (Plateau).....	5.5	9.7	8.7
19th (Rift).....	10.5	13.6	14.1
Difference.....	5.0	3.9	5.4

On the ascent of Gebel Ma'in, 600 metres above the valley, only 11·3 was recorded at 2.40 p.m., and keen wind was blowing, though the general conditions had not changed.

It may therefore be stated, as a first approximation, that the *temperature-difference between the Sinai plateau and the country south of the Transverse Divide* mentioned in the General Report *may be taken as from 4 to 5° C.*

Observations for December, 1898.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 2	7.30 a.m.	16·3	714	Wadi Ethmoi and Wadi Kyd	Cloudless.
„ „	11.10 a.m.	27·6	714·6	do.	Fine, hot.
„ „	1.10 p.m.	27	714	do	Still, hot.
„ „	4.15 p.m.	23·7	713	do.	Still, hot.
„ „	10.45 p.m.	15·4	712·9	do.	....
„ 3	6.30 a.m.	12·8	712	do.	Hot, fine, small clouds, but still.
„ 4	7.— a.m.	11·3	706·9	Higher up Wadi Kyd	Fine, clear, still.
„ 5	Early	8·9	707	do.	Still, fine.
„ „	9.— a.m.	20·3	708·9	do.	Still, hot.
„ „	5.30 p.m.	17·5	683·9	Wadi Humr	Fine.
„ „	8.— p.m.	15	684·3	do.	do.
„ 6	6.30 a.m.	8·9	682·7	do.	Fine, still day.
„ „	7.45 p.m.	15·4	683	do.	....
„ 7	6.50 a.m.	7·9	682·5	do.	Fine, still day.
„ „	8.— a.m.	13	682·6	do.	....
„ „	7.10 p.m.	16	682·4	do.	....
„ „	8.30 p.m.	13·8	682·7	do.	....
„ 8	Morning	8	683·9	do.	Clear, still.
„ „	7.10 p.m.	10·5	684·4	do.	Clear, still.
„ 9	7.— a.m.	7·8	685·2	do.	Still, fine.
„ „	9.— a.m.	16·3	685·8	do.	....
„ „	11.30 a.m.	23	..	do.	Air still, few clouds in western sky.
„ „	3.— p.m.	19·2	..	do.	....

Observations for December, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 9	5.30 p.m	15·8	675·4	Head of Wadi Humr	....
„ „	8.0 p.m.	15	675·4	do.	Still, a little cloudy.
„ 10	6.45 a.m.	12·5	674·4	do.	Still, a little cloudy.
„ „	3.50 p.m.	11·3	..	Summit of Gebel Mazea	Cloudy, breeze.
„ „	7.50 p.m	14·4	674·6	Head of Wadi Humr	....
„ 11	7.30 p.m.	11·1	687·1	Wadi Ethmid	Still, clear.
„ 12	7.— a.m.	11	665·4	do.	Little windy, masses of clouds all day.
„ „	7.— p.m.	13·3	663·9	do.	do.
„ 13	7.15 a.m.	9·4	663	do.	Slight breeze and considerable cloud. Evening clear again.
„ „	9.45 a.m.	13·8	663·6	do.	....
„ „	9.— p.m.	16·3	712·5	Wadi El Tema	....
„ 14	6.45 a.m.	10·8	712	do.	Still, clear, then cloudy and breeze to clear.
„ „	7.5 p.m.	14·4	713·1	do.	....
„ 15	7.— a.m.	5·7	713·6	do.	Clear, then white clouds.
„ „	6.30 p.m.	13	715·8	do.	Still, clear.
„ 16	7.40 a.m.	8·6	716·6	do.	White, clouds all day, no wind, hot sun.
„ „	12.40 p.m.	22·5	716·9	do.	do.
„ „	3.— p.m.	20·6	716·9	do.	....
„ „	5.50 p.m.	15·8	717·2	do.	....
„ „	8.— p.m.	12·4	717·2	do.	....
„ 17	6.50 a.m.	7·8	717·3	do.	Clear, still. Light puffs of wind to clear, still.
„ „	7.— p.m.	15·3	731·8	Wadi Gebila and Wadi Kyd	....
„ 18	6.45 a.m.	12·8	730·4	do.	Still, cloudy.
„ „	8.20 a.m.	16·1	730·4	do.	Still, clearing, then breeze, hot, misty.
„ „	5.30 p.m.	18	729·9	do.	Still, clear.
„ „	Night	13·8	730·2	do.	Still, clear.
„ 19	6.30 a.m.	8·7	729·2	do.	Clear, still, chilly.
„ „	8.30 a.m.	15·2	729·9	do.	Hot, still.
„ „	6.40 p.m.	19·8	739·2	Mouth of Wadi Gebila	Still, thin misty clouds
„ „	9.— p.m.	18·1	739·2	do.	do.
„ 20	7.— a.m.	19·2	738·2	do.	Still, cloudy.
„ „	8.— a.m.	19·8	738·2	do.	Still, cloudy. In afternoon at 3.15 breeze and cloudy
„ „	6.15 p.m.	21	736·5	do.	Cloudy, still.
„ „	9.15 p.m.	19·2	736·8	do.	Warm and cloudy.
„ 21	6.40 a.m.	16·8	736·1	do.	Nearly clear.
„ „	9.— a.m.	20·6	738·3	do.	Breeze, few clouds.

Observations for December, 1898 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1898					
Dec. 21	12.45 p.m.	22·6	750·2	Sea-level, Ras Atantur	Fresh breeze, clouds.
„ „	7.— p.m.	17·8	745·5	Mouth of Wadi Kyd	Quite still.
„ „	9.30 p.m.	16·7	746·8	do.	Quite still.
„ 22	7.— a.m.	13	748·2	do.	Clear, chilly.
„ „	9.— a.m.	18·8	749·0	do.	At 4 pm. breeze, clouds
„ „	Evening	16·5	749·7	do.	Still, clear.
„ „	Evening	13·9	750·1	do.	Still, clear.
„ 23	6.30 a.m.	12	750·1	do.	....
„ „	9.- a.m.	17·9	751·4	do.	Clear, light breeze.
„ „	7.— pm..	15·3	740	Junction Wadi Kyd and Wadi Beda	Hot, still to slight breeze.
„ „	?.9 p.m.	13·7	740	do.	Clear, still.
„ 24	6.50 a.m.	12·8	737·7	do.	Clear, still.
„ „	8.35 a.m.	16·7	738·3	do.	Quite clear, still.
„ „	6.40 p.m.	14·4	735·2	do.	....
„ „	8.10 p.m.	17·3	735·5	do.	....
„ 25	7.30 a.m.	13	736·2	do.	Still and fine.
„ „	4.20 p.m.	15	726·2	Mouth of Wadi Zerig Yahamed	Brilliantly fine, still.
„ „	6.40 p.m.	12·8	726·2	do.	Colder, fine.
„ „	9.30 p.m.	10·8	726·6	do.	Quite still, clear moonlight.
„ 26	6.45 a.m.	8·0	726·5	do.	Air still, chilly.
„ „	8.40 a.m.	10·5	727·7	do.	Fine.
„ „	6.— p.m	12·8	728·4	do.	Air still, chilly.
„ „	9.30 p.m.	10·0	729·6	do.	Small fleecy clouds.
„ 27	6.20 a.m.	6·4	730·8	do.	Air still.
„ „	8.15 a.m.	8·3	732·2	do.	Fine, air still.
„ „	6.— p.m.	9·5	711·9	Centre of Wadi Yahamed	Air still, fine.
„ „	10.30 p.m.	8·0	712·3	do.	Air still.
„ 28	7.— a.m.	3·0	712·9	do.	Still, chilly, fine
„ „	6.25 p.m.	8·2	711·6	do.	Still, few fleecy clouds
„ „	10.— p m.	8·6	710·9	do.	Still.
„ 29	7.— a.m.	6·0	709·7	do.	Sky clear, still.
„ „	12.— p.m.	8·9	..	Summit of Um Ekhlis (nearly 1000 metres above valley)	....
„ „	3.— p.m.	10·2	..	do.	....
„ „	7.15 p.m.	8·0	708·7	Centre of Wadi Yahamed	Fine, still.
„ 30	7.— a.m.	2·9	708·3	do.	....
„ „	10.— a.m.	14·2	710·3	do.	Air still, fine.
„ „	12.— p.m.	17·0	..	Gorge of Wadi Yahamed	....
„ „	3.— p.m.	12·5	..	do. (higher)	Clouds drifting up from west.
„ „	5.30 p.m.	7·8	675	Foot of Gebel Sabbagh	....
„ 31	6.— a.m.	2·5	674·6	do.	Still fine, a few clouds
„ „	2.10 p.m.	5·3	..	Summit of Gebel Sabbagh	....

The lowest recorded temperature for the month of *December* was noted on the *31st* at *6 a.m.* at the foot of Gebel Sabbagh (Central Range) = 2°·5 C., the *highest* on the 2nd (no record for the 1st) in Wadi Kyd, viz., *27°·6* at *11.10 a.m.*

The Morning Average 6 to 8 a.m. = *9°·8* C. (29 readings), the *Maximum* being *19°·2* C. at 7 a.m. on the 20th (month of Wadi Gebila). *Minimum 2°·5* C. at 6 a.m. Gebel Sabbagh.

Too few *Midday* temperatures were taken to form an average; such as were noted vary from 5°·3 C. on the summit of Sabbagh (at 2.10 p.m. on the 31st), and 10°·2 C. on summit of Um Ekhlis (on the 29th at 3 p.m.), to 22°·6 C. at sea-level, Gulf of Akaba, (at 12.45 p.m. of the 21st), and 27° C. (at 1.10 p.m. of the 2nd) in Wadi Kyd.

Evening temperatures (6 to 8 p.m.) (27 readings). Most of the readings were taken about 7 p.m., the time of return to camp.

Average = 14°·3 C. *Maximum* 21° C. on the 20th, at 6.15 p.m. (mouth of Wadi Gebila). *Minimum* 7°·8 C. on the 30th, at foot of Gebel Sabbagh.

Although no midday averages were taken, the regularity of difference for the preceding months may enable us to suggest a probable figure.

Average	Half October	November	December
Morning.....	20	11.3	9.8
Afternoon.....	28 8	19	17.3
Evening.....	24.9	16.2	14.3

Wind. A remarkable feature of this month was its freedom from wind Only on 10 out of the 31 days have breezes been recorded, and these always light and in the afternoon, with one exception, the night of the 24th.

Cloud. These were noted on 17 days, but usually small and fleecy. *Cirrus.* Only on the 12th, 13th and 16th were these in mass. There was lightning to the north on the 11th.

Snow. On the night of the 27th a heavy cloud came up over Gebel Sabbagh, the neighbouring summits remaining clear. When it lifted next morning the mountain was covered with snow, which was still lying thick on the slopes when we ascended it on the 31st, the result being that two of the Arabs were frost-bitten, and one developed night-blindness.

Observations for January, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 3	2.20 p.m.	6.2	..	Summit of Um Adowi	Previous days fine, still, few clouds, light breeze.
„ 4	3.20 p.m.	10·3	..	Summit of Gebel Barakat	Still, clear, warm.
„ „	Evening	6·9	707·5	Foot of Um Adowi	....
„ 5	7.— a.m.	5·9	704·7	do.	Still, fine.
„ „	9.15 a.m.	12·7	706·4	do.	Still, clear.
„ 6	3.15 p.m.	14·0	..	Summit of Gebel Battach	Misty.
„ „	8.30 p.m.	7·0	729·1	Centre of Um Adowi	Clear, still.
„ 7	7.— a.m.	5·4	727·7	do.	....
„ 8	6.— p.m.	11·9	737·9	Lower part of Um Adowi	Gusts of wind.
„ „	8.20 p.m.	10·4	738·6	do.	Occasional gusts of wind.
„ 9	6.30 a.m.	2·0	741·2	do.	Still, clear.
„ „	8.10 a.m.	6·0	741·9	do.	Snow on Jebel Zebir.
„ „	5.45 p.m.	10·6	742·7	do.	Still, clear.
„ „	9.30 p.m.	6·4	743·7	do.	Still, clear, fine. Frost at night.
„ 10	6.35 a.m.	3·3	745·2	do.	Still, clear.
„ „	8.30 a.m.	5·6	745·7	do.	Clear, still.
„ „	6.— p.m.	12·2	759·2	Nebk (sea-level)	Little cloudy.
„ „	7.10 p.m.	12·9	759·7	do.	Breeze, cloudy.
„ „	9.— p.m.	12·4	759·8	do.	Land breeze.
„ 11	8.40 a.m.	15·4	758·7	do.	Windy, cloudy, about 4 o'clock still.
„ 12	8.— p.m.	9·0	747	Foot of Gebel Giada	Zodiacal light, clear, still.
„ „	9.50 p.m.	13·0	746·9	do.	Still, clear
„ 13	7.45 a.m.	13·4	748	do.	Windy cloudy.
„ „	9.— a.m	16·0	748·2	do.	Thin clouds, fresh breeze all day, still at night.
„ „	9.30 p.m.	10·3	755·2	Aad Bay	....
„ 14	8.— a.m.	14	754·4	do.	Clear, still, light breeze, few clouds at noon.
„ „	9.40 p.m.	14·9	754·7	Sherm	Zodiacal light and windy. Windy night.
„ 15	8.— a.m.	13·7	754·9	do.	Still, but breeze about noon. Rain in night and early.
„ 16	Morning	17·4	753·2	do.	Cloudy, breeze.
„ „	12.— p.m.	19·2	751·4	do.	Clearing.
„ „	2.15 p.m.	18·4	751·1	do.	Strong wind.
„ „	4.30 p.m.	16·3	750·8	do.	....
„ „	6.— p.m.	15·4	750·7	do.	Blowing hard.

Observations for January, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 17	9.30 a.m	11·3	752·4	Sherm	Blowing hard. Wind moderated about 4 p.m.
„ „	7.— p.m.	10·4	752·4	Hedemia Bay	Still, some clouds.
„ „	9.— p.m.	10·4	752·7	do.	Cloudy, chilly. Wind in night.
„ 18	7.15 a.m.	10·6	755·7	do.	Still.
„ „	9.— a.m.	14·4	757·2	do.	Still, fine.
„ „	10.45 a.m.	17·8	..	Low hills * west of St. 8	West breeze, clear.
„ „	2.— p.m.	17·3	..	do. (Sheet 11) St. 9	Breeze.
„ „	5.— p.m.	14·4	..	do. St. 10	Still, clear.
„ „	6.45 p.m.	10·4	757·5	Hedemia Bay	Clear, no clouds.
„ „	8.— p.m.	9·2	756·7	do.	Still, clear.
„ 19	7.— a.m.	8·2	759·3	do.	....
„ „	8.35 a.m.	14·4	759·1	do.	....
„ „	11.30 a.m.	18·3	..	Sheet 11 Low hills S. of St. 11	S.W. breeze.
„ „	3.30 p.m.	17·8	..	Sheet 11 do. 12	Windy.
„ „	5.30 p.m.	15	..	Sheet 11 do. 13	W. breeze.
„ 19	9.10 p.m.	10	757·7	Ras Mohammed	Clear, still.
„ 20	7.10 a.m.	8·3	757·8	do.	Clear, still.
„ „	9.— a.m.	12·8	759·7	do.	....
„ „	11.15 a.m.	17·5	..	Sheet 11, St. XIV.	Light breeze, east.
„ „	12.20 p.m.	20	..	do. XV.	N.E. breeze.
„ „	1.50 p.m	17·8	..	do. XVI.	Breeze light.
„ „	3.15 p.m.	18·3	..	do. XVII.	....
„ „	4.35 p.m.	16·7	..	do. XVIII.	Westerly breeze, light, fine.
„ „	Evening	14·4	..	do. XIX.	....
„ „	10.30 p.m.	10·9	758·2	Ras Mohammed	Still.
„ 21	7.40 a.m.	12·7	758·3	do.	Still, clear.
„ „	9.— a.m.	14·4	759·3	do.	Still, clear.
„ „	11.— a.m.	17·8	..	Sheet 11, St. XX.	S.E. breeze, wind changing.
„ „	2.— p.m.	17·8	..	do. XXII.	W. breeze.
„ „	4.35 p.m.	15	..	do. XXIII.	W. breeze.
„ „	Evening	11·7	744·4	Wadi Hashubi	Still, clear.
„ 22	7.10 a.m.	8·9	740·4	do.	....
„ „	8.10 a.m.	14·9	741·2	do.	....
„ „	1.30 p.m.	17·9	..	Sheet 11, St. XXV.	West wind, some cloud.
„ „	6.— p.m.	14·4	738·6	Wadi Hashubi	Still.
„ 23	7.15 a.m.	7·0	739	do.	Still, clear.
„ „	8.20 a.m.	11·7	740·2	do.	do.
„ „	12.20 p.m.	19	..	Sheet 11, St. XXVII.	do.
„ „	2.30 p.m.	21	..	do. XXVIII.	Clear, W. breeze.
„ „	5.15 p.m.	16·1	..	do. XXIX.	West breeze.
„ „	9.30 p.m.	10·0	735·5	Wadi Madsus	Clear, still.

* These stations are on low hills between Sherm and Ras Mohammed and are shown on the field-sheets kept in the Survey Department.

Observations for January, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Jan. 24	7.10 a.m.	6·7	735·7	Wadi Madsus	....
„ „	8.45 a.m.	12·2	756·4	do.	....
„ „	12.40 p.m.	15·4	..	Summit Gebel Hedemia (300 metres above valley).	Still, clear.
„ „	8.30 p.m.	10·6	736·1	Wadi Madsus.	do.
„ 25	6.45 a.m.	6·7	735·3	do.	do.
„ „	8.30 a.m.	11·1	736·4	do.	do.
„ „	12.10 p.m.	15	..	Gebel Wa'ar (about 200 metres above camp).	Clear, slight breeze.
„ „	8.35 p.m.	9·6	..	Wadi Madsus.	....
„ „	10.— p.m.	9·4	736·4	do.	Still, clear.
„ 26	7.— a.m.	13·3	736·2	do.	do.
„ „	9.50 a.m.	16·7	737·6	do.	West breeze.
„ „	3.30 p.m.	16·1	..	Gebel Um Markha	do.
„ „	6.— p.m.	15·0	..	Head of Wadi Awaja.	Still, clear
„ „	8.45 p.m.	10·6	720·4	do.	do.
„ 27	6.— p.m.	14·4	721·8	do.	Still, a few clouds.
„ „	8.20 p.m.	12·8	722·3	do.	Still, clear.
„ 28	7.— a.m.	10·8	722·4	do.	do.
„ „	8.25 a.m.	13·8	723·2	do.	Still.
„ „	12.30 p.m.	19·7	740·1	Gebel Nimr (low hill)	Still, hot.
„ „	4.45 p.m.	17·1	..	Gebel Dajilat.	Few clouds.
„ „	7.45 p.m.	14·2	737·6	Wadi Aad.	....
„ „	Later	13·8	738	do.	Clear, still.
„ 29	8.15 a.m.	14·4	737·2	do.	Still, clear.
„ „	1.10 p.m.	19·7	..	Sheet 11, St. XXXIX.	Still, brilliantly fine, no clouds.
„ „	9.— p.m.	15	735·8	Wadi Aad.	Still, few clouds.
„ 30	10.20 a.m.	20	736·1	do.	Still, clear.
„ „	4.10 p.m.	17·2	..	Sheet 11, St. XLII (about 500 metres above camp)	do.
„ „	6.45 p.m.	17·2	735·6	Wadi Aad.	do.
„ „	8.30 p.m.	12·8	735·7	do.	....
„ 31	8.35 a.m.	15·9	737·3	do.	Still, fine.
„ „	11.— a.m.	20	738·2	do.	Still, some clouds.
„ „	3.— p.m.	23·3	737·1	do.	Still, clear.
„ „	6.— a.m.	17·2	737·8	do.	Still.

The *Maximum* noted for January was 23°·3 C. at 3 p.m., on the 31st in Wadi Aad. *Minimum*, 2° C. at 6.30 a.m. on the 9th in Wadi Um Adowi, on which day there was frost at night, and Zebir was covered with snow.

Morning average (mainly 6 to 8 a.m.) = 10° C. (21 readings).

Maximum, 16°·9 C. at 8.35 a.m. on 31st in Wadi Aad.
Minimum, 2° C. at 6.30 a.m. on 9th in Wadi Um Adowi.

Afternoon averages=17°·3 C. (17 readings) the *Maximum* noted being 23°·3 C. at 3 p.m. on 31st in Wadi Aad, the *Minimum* 6°·2 C. at 2.20 p.m. on the 3rd, on summit of Um Adowi.

Evening averages = 12°·8 C. (24 readings), the *Maximum* record being 17°·2 C. at 6.45 p.m. on the 30th, and again at 6 p.m. on the 31st, both in Wadi Aad, the *Minimum* 6°·9 C. on evening of the 4th, foot of Um Adowi.

Practically, the cold period began about the 25th of December, 1898, and was more or less marked till the 26th of January. From the 30th December to the 10th January there was no record over 14° C.

The wind observations were exceptionally numerous in January owing to our lengthened stay near the Gulf of Akaba. *Wind* was noted on 17 days, blowing exceptionally hard at Sherm from 16th to 18th, with rain on the night of the 15th. *Cloud* was noted on 13 days, but mostly only of the small fleecy type. Often when on the central summits it was perfectly still and clear, the waters of the Gulf of Akaba were seen to be foam-tipped, indicating the action of strong winds.

Observations for February, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Feb. 1	3.— p.m.	20·6	..	Sheet 12. St. II*	Misty, cloudy.
„ „	5.— p.m.	20·6	..	„ St. III	Cloudy.
„ 2	7.40 a.m.	15·6	736	Wadi Aad	Still, clear.
„ „	8.35 a.m.	17·8	..	do.	do.
„ „	11.45 a.m.	21·7	..	Sheet 12. St. IV	do.
„ „	5.— p.m.	18·9	..	„ St. V	do.
„ 3	7.15 a.m.	13·3	714·7	Head of Wadi Aad	do.
„ „	8.15 a.m.	15·2	..	do.	do.
„ „	Noon	15·6	..	Summit of Haimar (nearly 1000 metres above camp)	Cloudy, hot, still.
„ „	Evening	16·5	714·2	Head of Wadi Aad	Still, clear.
„ „	Later	16·7	714·7	do.	do.
„ 4	7.15 a.m.	15	712·6	do.	do.
„ „	?8.15 a.m.	18·3	..	do.	do.
„ „	Noon	18	..	Summit of Aad (about 900 metres rise)†	....
„ „	7.15 p.m.	16·4	710·1	Head of Wadi Aad	Big wind in night.
„ 5	7.45 a.m.	15	710·3	do.	Misty, still.
„ „	1.30 p.m.	13·2	..	Summit of Aad El Gharbi (about 600 metres)†	Strong west wind.
„ „	7.10 p.m.	15·4	710·7	Head of Wadi Aad	At 3.30 S.W. wind, hazy, then at 7 clear sky, gusts of wind.
„ 6	7.30 a.m.	11·7	711·3	do.	Still, hazy.
„ „	8.15 a.m.	13·3	711·7	do.	Windy, west wind, white clouds in day, evening still.
„ 7	2.— p.m.	17·9	..	Gebel Khurum	West wind, cloudy.
„ „	7.— p.m.	14·8	733·1	Wadi Mnidri	Still.

* Low stations in or near Wadi Aa'd.

† Heights above camp.

Observations for February, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Feb. 7	8.45 p.m.	14·8	733	Wadi Mnidri.	Still, clear.
„ 8	1.30 p.m.	17·8	..	Summit of Mabledge (300 metres)*	Light breeze.
„ 9	12.30 p.m	20·6	720·8	Wadi Letih	Clear, hot.
„ „	6.30 p.m.	16·3	718·2	do.	Still, clear.
„ 10	8.30 a.m.	15	716·7	do.	do.
„ „	12.— p.m.	17·8	717·4	do.	Clouding.
„ „	6.— p.m.	13·8	717·2	do.	Raining.
„ 11	7.20 a.m.	11·1	717·9	do.	Clear, still.
„ „	12.45 p.m.	9·2	..	Summit of Mobera (600 metres)*	Showers, rain, heavy cloud. At 2.45 N.W. clouds.
„ „	9.30 p.m.	11·7	719·4	Wadi Letih	Clear, still.
„ 12	7.— a m.	9·4	719·3	do.	do.
„ „	10.30 a.m.	15	..	Sheet 12. St. XVI. Higher up Wadi Letih	Clear, fine.
„ „	2.30 p.m.	15·2	..	do.	West breeze, clouds.
„ „	3.30 p.m.	15	..	do.	White clouds.
„ „	4.15 p.m.	13·3	..	do.	West breeze.
„ „	5.20 p.m.	12·4	694·8	Head of Wadi Letih	Still, clear.
„ 13	7.15 a.m.	9·2	693·9	do.	do.
„ „	8.10 a.m.	13	694·6	do.	do.
„ „	12.— p.m.	11·1	..	Gebel Letih (500 metres)*	East breeze, clouds.
„ „	7.40 p.m.	12·8	695·2	Head of Wadi Letih	Clear, still.
„ 14	7.15 a.m.	11·7	693·7	do.	do.
„ „	10.45 a.m.	14·2	..	Sheet XXXV (300 metres)*	Clear, breeze.
„ „	about 2 p.m.	15	..	Sheet XXXVI (500 metres)*	Clear, still.
„ 15	8.— a.m.	12·8	691·7	Head of Wadi Letih	do.
„ „	3.50 p.m.	12	..	Summit of Ethnarbi	Still, f ,w clouds.
„ „	8.— p.m.	12·8	691·2	Head of Wadi Letih	Still, clear.
„ 16	..	..	..	....	....
„ 17	7.— p.m.	12·2	694·2	Wadi Um Zeinig	Still, clear.
„ „	9.30 p.m.	12·2	693·6	do.	do.
„ 18	7.20 a.m.	11·0	691·8	do.	Clear, still.
„ „	Afternoon	15·6	..	Summit Um Zeinig (400 m.)*	West breeze, clear.
„ „	7.— p.m.	15·6	691·9	Wadi Um Zeinig	Clear, still.
„ „	8.50 p.m.	14·4	691	do.	....
„ 19	1.— p.m.	20·0	690·6	do.	Clear, still.
„ „	6.30 p.m.	15·8	690·6	do.	Gusts of wind.
„ 20	7.10 a.m.	13·9	689·8	do.	Cloudy.
„ „	9.30 a.m.	17·5	690·4	do.	Clearing.
„ „	2.30 p.m.	17·8	689·7	do	Wind and cloud.
„ „	5.10 p.m.	16·7	689·1	do.	Gusts of wind.
„ „	8.— p.m.	13·9	689·2	do.	....
„ 21	8.30 a.m.	11.1	688·4	do.	Still, clear.
„ „	1.20 p.m.	11·7	..	Summit El Khor (400 metres)*	do.
„ „	3.— p.m.	13·2	..	Wadi Um Zeinig	West breeze.
„ „	5.10 p.m.	10·0	..	Sheet 12. St. XXXIII (low)	West wind .

* The heights shown are above valley level.

Observations for February, 1899 (*continued*).

Date	Time	Temperature centigrade	Pressure millimetres	LOCALITY	REMARKS
1899					
Feb. 21	7.30 p.m.	8·3	694·3	Wadi Mazea	Very misty, few clouds.
„ 22	7.30 a.m.	5·0	696·4	do.	Still, clear.
„ „	2.40 p.m	8·0	..	Sheet 12. St. XXXIV (700 metres) Gebel Sahara	Clear, very still.
„ „	4.45 p.m.	8·9	..	Sheet 12. St. XXXV (700 metres) Gebel Sahara	Still, little mist.
„ „	8.— p.m.	10·0	697·5	do.	....
„ „	9.40 p.m.	8·3	697·6	Wadi Mazea	Still, clear.
„ 23	7.— a.m.	5·0	696·7	do.	do.
„ „	8.30 a.m.	8·9	696·9	do.	do.
„ „	12.— p.m.	10·6	..	St. XXXVI. (600 metres)	Clear, still.
„ „	3.30 p.m.	12·8	..	do.	do.
„ „	7.— p.m.	15·2	696·7	Wadi Mazea	do.
„ 24	7.30 a.m.	8·3	696·4	do.	do.
„ „	8.30 a.m.	12·2	696·8	do.	do.
„ „	11.20 a.m.	13·1	..	Sh. 12. XXXIII. (300 metres)	do.
„ „	4.— p.m.	12·8	..	Gebel Ergain (400 metres)	East breeze.
„ „	8.— p.m.	15	717·8	Wadi Letih (same camp 9th to 12th)	Clear, still.
„ 25	7.15 a.m.	15	715·6	do.	do.
„ „	8.15 a.m.	17·8	715·7	do.	do.
„ „	1.30 p.m.	20·6	..	Sh. 12. St. XXXIX (300 m.)	East breeze.
„ „	5.30 p.m.	18·3	..	Sheet XL (low)	....
„ „	8.— p.m.	15	717·8	Wadi Letih	Still, clear.
„ 26	7.15 a.m.	13·3	714·2	do.	Still, fine.
„ „	8.25 a.m.	18·3	713·7	do.	....
„ „	12.— p.m.	24·4	..	St. XLI (200 metres)	South wind, hazy.
„ „	4.5 p.m.	21·1	..	St. XLII (200 metres)	West wind.
„ „	7.30 p.m.	19·4	714	Wadi Letih	....
„ 27	7.15 a.m.	15·2	715·2	do.	S.E. wind, clear.
„ „	8.30 a.m.	17·8	715·6	do.	Still, clear.
„ „	11.30 a.m.	21·1	..	Gebel Um Ebeirig (low)	Still, misty, haze and white clouds.
„ „	1.30 p.m.	21·4	..	Wadi Gafar da Falla	S.E. breeze.
„ „	4.45 p.m.	17·0	..	Gebel Beidha (nearly 300)	Misty, S.E. breeze.
„ „	7.— p.m.	16·4	725·3	Wadi Gafar da Falla	Air still.
„ „	8.30 p.m.	16·1	725·3	do.	Still, clear.
„ „	10.— p.m.	15·3	725·4	do.	do.
„ 28	7.30 a.m.	11·7	726·2	do.	do.
„ „	8.40 a.m.	15·0	726·4	do.	do.
„ „	11.— a.m.	17·8	..	Gebel Beidha El Asrar (low)	Clear, S.E. breeze.
„ „	12.30 p.m.	21·1	..	Wadi Um Bsilla	do.
„ „	4.20 p.m.	18·2	..	Gebel..... (200 metres)	East breeze.
„ „	5.45 p.m.	19·4	..	Wadi Naas	do.
„ „	7.— p.m.	17·0	728·6	do.	Still, clear, zodiacal light.

* Heights shown are above valley level. The numbers indicate low valley stations whose exact position is shown on the original field-sheets.

The *Maximum* noted for February was *24°·4 C.* at 12 p.m. on summit of station above Wadi Letih (26th), a south wind blowing. *Minimum*, *5° C.* at 7.30 p.m. on 22nd, and at 7 a.m. on the 23rd in Wadi Mazea among the hills.

21 Morning Readings give an average of 11°·9 C. the *Maximum* noted being *15°·6 C.* at 7.40 a.m. on the 2nd in Wadi Aad, the *Minimum*, *5° C.* at 7 and 7.30 a.m. in Wadi Mazea (see above).

The comparatively low average for the afternoon temperatures (25 readings) = 16°·5 C. is due to the faet that a large number of these were taken on mountain summits. The *Maximum* was *24°·4 C.* at 12 p.m. (for locality see above), and the *Minimum*, *8°·0 C.* at 2.40 p.m., on the summit of Gebel Sahara. (500 metres.)

24 Evening Temperatures gave an average of 14°·7 C., the *Maximum* being *20°·6 C.* at 5 p.m. on the 1st (St. I, Sh. 12, see map). *Minimum*, *8°·9 C.* at 4.45 p.m. on summit of Gebel Sahara.

The country traversed may be divided into two regions, one a closed mountain district only entered by a narrow gorge at the head of Letih, and the other more open country; 13 days were spent in the former, 15 in the latter. The temperature rose ten times over 20° C. in the low country, and only fell once below 10° C. In the mountain district, on the contrary only once was 20° C. just reached, while ten times the temperature was 10° C. or under, so that the contrast due to geographical position is well marked, and unfortunately at the same time reduces the value of the averages.

Rain. A heavy rainstorm burst over the Hamar range on the 11th, in a few minutes torrents pouring in cascade and waterfall down the sides, dislodging huge fragments of rock. On the station opposite, Gebel Mobera, we escaped with only three falls of hail the storm area being sharply marked off about 100 metres from the summit. The storm ended as abruptly as it began, and at night the record was again clear and still. Rain was also noted on the 10th, mainly small showers.

Wind. The early part of the month was very windy, the night of the 4th being unpleasantly noticeable for its gusts, while on the afternoon of the 7th the tents were pitched as high up a small boulder valley as possible in order to escape their effect. This was probably the most windy month of any yet recorded, ten days of heavy wind being noted, and ten of light afternoon breezes. The first-named were mainly from the west or S.W., while the light breezes were chiefly east or S.E.

Cloud. During the first three weeks the afternoons were frequently misty or cloudy, but after the 21st, the days were generally clear, especially morning and evening and while the eastern breezes were blowing.

Observations for March, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
March 1	7.10 a.m.	12·8	729·4	Wadi Na'aj	Still, misty.
„ „	8.10 a.m.	16·1	729·8	do.	Still, clear.
„ „	2.25 p.m.	18·3	..	Summit Gebel Ajuaf (500 m.)	East breeze.
„ „	Evening	18·3	729·5	Wadi Na'aj	Still.
„ 2	7.30 a.m.	12·8	728·7	do.	Still, cloudy.
„ „	10.30 a.m.	18·9	729·6	do.	do.
„ „	12.50 p.m.	22·8	727·9	do.	Still, few clouds.
„ „	3.50 p.m.	23·3	726·7	do.	Still, hazy.
„ „	5.20 p.m.	22·2	726·3	do.	do.
„ „	9.— p.m.	16·1	726·7	do.	Still, clear.
„ 4	9.15 a.m.	19·5	728·7	Wadis Gebila and Kyd	do.
„ „	9.— p.m.	18·3	727·8	do.	Rain Thunder and Thunder showers, unsettled.
„ 5	7.10 a.m.	16·1	727·7	do.	Clear, still.
„ „	3.50 p.m.	16·0	..	Gebel Madsus (700 metres)	Misty, white clouds.
„ „	8.30 p.m.	19·2	725·8	Mouth Wadi Madsus	Clear, still.
„ 6	7.— a.m.	12·8	725·5	do.	do.
„ „	8.15 a.m.	17·5	704·4	Head of Wadi Madsus	do.
„ 7	7.30 a.m.	13·3	705·2	do.	do.
„ „	10.15 a.m.	16·7	..	Station (500 metres)	....
„ „	1.— p.m.	20·0	..	do.	S.W. breeze.
„ „	4.— p.m.	15·8	..	do.	....
„ „	6.15 p.m.	18·3	705·1	Head of Wadi Madsus	Clear, still.
„ 8	1.30 p.m,	19·4	..	Station (400 metres)	West breeze.
„ „	4.15 p.m.	18·3	..	Another Station (400 metres)	Faint breeze, clear.
„ „	7.40 p.m.	18·9	704.2	Head of Wadi Madsus	Clear, still.
„ 9	7.12 a.m.	12·8	703·6	do.	do.
„ „	8.15 a.m.	16·7	704·5	....	....
„ „	12.30 p.m.	20·6	..	St. Gebel Hamra Er Rahab (600 metres)	Clouding, E. breeze.
„ „	3.30 p.m.	20	..	do.	Cloudy, still.
„ „	4.40 p.m.	17·2	..	Another Station (600 metres)	Some clouds.
„ „	8.25 p.m.	19·2	683·8	Head Wadi Sai'amin	Clear, still.
„ 10	7.30 a.m.	13·3	684·5	do.	do.
„ „	12.— p.m.	17·8	..	Gebel Um Aleg (700 metres)	Hazy, nearly clear, East breeze.
„ „	1.— p.m.	16·7	..	2nd Station do.	Hazy, still.
„ „	4.20 p.m.	14·4	..	3rd Station do.	do.
„ „	8.5 p.m.	17·8	687·3	Head Wadi Sai'amin	Still.
„ „	10.— p.m.	17·8	687·7	do.	Still, clear.
„ 11	7.10 a.m.	15·6	687·5	Head of Wadi Sai'amin	Still, clear.
„ „	12.30 p m.	20·6	..	Summit of Sowila (500)	Hazy, still.
„ „	2.45 p.m.	21·1	..	do.	do.
„ „	5.50 p.m.	20·6	687·9	Head of Wadi Lij	Clear, still.
„ 12	8.10 a.m.	17	688·7	do.	do.
„ „	12.30 p.m.	22	688·4	do.	Breeze.
„ „	3.30 p.m.	22·2	688·3	do.	Still, clear.

* Heights given above valley level.

Observations for March, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Mar. 13	6.50 a.m.	7·2	691·4	Head of Wadi Lij	Still, clear. Then N.E. breeze.
„ „	8.— a.m.	13·3	686·0	do.	Still, clear.
„ 14	7.— a.m.	11·3	687·8	do.	do.
„ „	9.— a.m.	18·3	686·4	do.	do.
„ „	11.— a.m.	20·0	688·3	do.	do.
„ „	1.— p.m.	21·1	688·4	do.	Breeze.
„ „	3.— p.m.	22·8	687·7	do.	....
„ „	5.— p.m.	20·8	686·8	do.	Still, cloudy.
„ „	7.— p.m	18·2	686·8	do.	do.
„ 16	7.— a.m.	18·3	710·4	Head of Wadi Madsus	Still, heavy, close.
„ „	8.30 a.m.	20·0	710·9	do.	Heavily clouded.
„ „	2.30 p.m.	21·1	..	Gebel Sailem (500 metres)	do.
„ „	6.— p,m.	25·5	705·2	Head of Wadi Madsus	Cloudy, still.
„ 17	7.— a.m.	20·6	704·4	do.	do.
„ „	8.30 a.m.	22·8	704·6	do.	do.
„ „	1.— p.m.	26	..	Gebel Ethmemia (300 m.)	do.
„ „	5.10 p.m.	21·7	..	Gebel Akhmara	Cloudy, misty.
„ „	8.15 p.m.	23·3	723·9	Mouth of Wadi Madsus	Still, misty. Rain in night.
„ 18	7.10 a.m.	23·8	723·5	do.	Cloudy, still.
„ „	8.30 a.m.	20·6	723·6	do.	do.
„ „	10.40 a.m.	22·8	..	Station (300 metres)	Heavily clouded, foggy.
„ „	2.45 p.m.	19·4	..	do. (200 metres)	Later raining.
„ 19	6.40 a.m.	18·3	699·5	Wadi Abu Esherat	Cloudy, still.
„ „	8.— a.m.	19·4	700·1	do.	Misty.
„ „	3.— p.m.	20·0	..	Gebel Abu Esherat (500 m.)	Cloudy, breezes.
„ „	8.— p.m.	20·3	700·6	Wadi Abu Esherat	Light puffs of wind, some clouds.
„ 20	1.30 p.m.	21·4	..	Two stations 150 to 250 metres above valley	Some clouds, little hazy.
„ „	5.— p.m.	20·0	..		Hazy, still.
„ 21	7.30 a.m.	15·6	702·8	Wadi Abu Esherat	Still, clear.
„ „	4.30 p.m.	21·1	..	Station (300 metres)	Hazy still.
„ „	?10.30 p.m.	17·2	713·9	Wadi Um Zeireh	Still, clear.
„ 22	7.30 a.m.	17·2	714·9	do.	do.
„ „	8.40 a.m.	23·3	715·8	do.	do.
„ „	10.30 a.m.	27·2	..	St. XVI Stations 100 to	do.
„ „	12.— p,m.	23·9	..	St. XVII 200 m. above	North East breeze.
„ „	3.— p.m.	23·9	..	St. XVIII valley	Clear, North East breeze.
„ „	6.— p.m.	22·8	700·0	Wadi Gnai	Clear, still.
„ „	Later	21·0	700·3	do.	....
„ 23	6.30 a.m.	17·2	700·2	do.	Clear, still.
„ „	8.— a.m.	17·8	701·2	do.	do.
„ „	12.15 p.m.	21·7	..	St. XIX Both 400 m. above	Clear, E. breeze.
„ „	3.15 p.m.	23·9	..	St. XX valley	do.

* Heights given above valley level.

Observations for March, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
Mar. 23	7.— p.m.	23·3	708·5	Wadi Hamra	Little wind.
„ 24	7.— a.m.	15·6	707·6	do.	Still, clear.
„ „	8.— a.m.	20	708·1	do.	do.
„ „	9.40 a.m.	22·2	..	Stations both 500 m. above valley	Clear.
„ „	12.— a.m.	23·9	..		Still, clear.
„ „	7.30 a.m.	23·3	706·3	Wadi Hamra	do.

NOTE.—At this point the sling thermometer hitherto used was broken, and a smaller one, which had previously been compared with the standard one at Cairo, came into use.

„ 25	7.— a.m.	20·4	706·4	....	Still, clear.
„ „	10.30 a.m.	31·7	..	Hill Stations, 100 to 300 m. above valley	do.
„ „	12.30 p.m.	32·6	..		Few clouds, still,
„ „	Afternoon	31·7	..		Still, hazy.
„ „	10.— p.m.	25·3	706·4	Wadi Hamra	Still, clear.
„ 26	7.— a.m.	22·6	706·2	....	do.
„ „	10.— a.m.	35	..	....	Still, white cloudy.
„ „	1.10 p.m.	33·3	..	Station Gebel Beidha, 250 metres above valley	Squally, clouds.
„ „	2.30 p.m.	32·2	..		Clouds, E. wind.
„ „	6.— p.m.	30·8	713·5	Wadi Seyal Noma	Still, little clouds.
„ „	7.50 p.m.	27	713·5	do.	....
„ 27	8.— a.m.	27·2	712·8	do.	Cloudy, still. Heavily clouded during day.
„ „	7.— p.m.	27·7	710·8	do.	Still, drops of rain.
„ 28	7.20 a.m.	16·4	710·0	do.	High wind, N. clear. In afternoon wind went down.
„ „	9.— p.m.	17·2	730·3	Base Wadi Moghtut	Windy.
„ 29	6.45 a.m.	12·6	732·4	do.	do.
„ „	8.— a.m.	16	733·4	do.	Clear, breeze.
„ „	11.— a.m.	14·7	..	Stations 200 metres above valley	N.E. wind.
„ „	3.— p.m.	16·8	..		Clear, breeze.
„ „	8.— p.m.	17·4	751·4	Month of Wadi Gnai El Atshan	N. breeze, blowing at night.
„ 30	6.30 a.m.	14·4	752·4	do.	N.E. breeze.
„ „	12.30 p.m.	18·9	..	Stations 350 metres above valley	do.
„ „	2.— p.m.	18·9	..		do.
„ „	9.30 p.m.	17·6	752·8	....	do.
„ 31	No record			....	Still, clear.

Maximum noted for March, *35° C.*, on the 26th at 10 a.m., on Coastal Range near Gulf of Akaba. *Minimum 7°·2 C.* at 6.50 a.m. on the 13th (head of Wadi Lij), the only case of a record below 10° C.

24 *Morning* Readings gave an average of 16°·4 C., the *Maximum* being *27°·2 C.* at 8 a.m. on the 27th, in Wadi Seyal Noma, and *Minimum. 7°·2* C. as above.

The *afternoon* temperatures being mostly taken on summits, the *average* is too low, 24 readings giving *22° C.*; the *Maximum* was *35° C.* as above, the *Minimum 16°* at 3.50 p.m. on the summit of Gebel Madsus.

25 *Evening* temperatures give an average of *20°·6 C.*, the *Maximum* being 30°·8 C. at 6 p.m. on the 24, in Wadi Seyal Noma, *Minimum 13°·3 C.* at 8 p.m. on the 13th (head of Wadi Lij).

The month of March was, speaking generally, very equable, temperatures under 10° C. being only recorded once, while there were fifty over 20° C. (35 in the latter half of the month), and seven over 30° C., these latter occurring on the 25th and 26th.

Rain was noted on the 4th, 17th, 18th, and a few drops on the 27th. That of the 4th was connected with a severe thunderstorm, which so far as could be judged (the camp being entirely closed in by hills over 400 metres high), came up from the south, and burst over the Madsus drainage area, no trace of its effects being noted in the neighbouring valleys. This storm was of considerable importance to the expedition, as it filled all the waterpools in a normally waterless district. Like all those seen in Sinai it was marked by brilliant lightning and a torrential downpour of rain, which falling on the bare rock, produces a sound rivalling that of the thunder itself. In a few minutes a rapid torrent of brown mud, over 2 metres wide, was rushing down Wadi Kyd near the camp, but it had disappeared in the morning. On the 5th there was a second storm during the night, but no rain fell at the camp itself. The remaining records are those of ordinary showers.

Wind was recorded on 15 days away from the sea, this being chiefly in the form of afternoon N.E. and E. breezes, but near the Gulf of Akaba there were heavy N.E. and N. winds which blew steadily both day and night.

Cloud or mist was noted on 15 days, heavy clouds being especially marked on the 16th, 17th, and 18th, and again on the 26th and 27th.

Observations for April, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 1	7.30 a.m.	18°·3	748°·4	Near sea, Wadi Gnai El Atshan	Steady N.E. breeze all day on Gulf. Still, clear.
„ 2&3	Flying expedition to map in coast, N.E. wind night and day.				
„ 4	7.45 a.m.	19°·4	751°·5	Wadi Gnai El Atshan	Stiff breeze from N.E. clear.
„ „	1.— p.m.	20	..	Stations 250 metres on Coast range	Wind.
„ „	4.— p.m.	19°·7	..		Clear, moderate breeze.
„ „	8.40 p.m.	20°·4	753°·7	Dahab	Steady N.E. wind and windy night.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 5	6.30 a.m.	17·8	753·9	Dahab.	N.E. breeze.
„ „	8.— a.m.	19·4	754·9	do.	Clear.
„ „	1.40 p.m.	18·9	..	Stations 400 metres above camp	N.E. breeze.
„ „	4.— p.m.	19·4	..		N.E. wind.
„ „	7.30 p.m.	20	753·9	Dahab	N.E. breeze.
„ „	10.30 p.m.	19	754·0	do.	N.E. wind.
„ 6	6.30 a.m.	18·3	754·1	do.	N.E. breeze.
„ „	8.30 a.m.	19·4	754·9	do.	do.
„ „	4.15 p.m.	23·3	752·9	do.	Fresh breeze from N. to N.E.
„ „	5.15 p.m.	22·6	752·4	do.	
„ „	6.50 p.m.	20·3	752·5	do.	....
„ „	10.30 p.m.	20·6	752·7	do.	....
„ 7	7.— a.m.	20·6	751·6	do.	N.E. breeze.
„ „	8.— a.m.	22·1	752·2	do.	Light breeze.
„ „	12.— p.m.	22·1	..	Gebel Tellat Unsair (500 m. above sea)	Clear, light breeze.
„ „	4.— p.m.	23·5	..	Gebel Um Isma	Cloudy, still,
„ „	7.30 p.m.	23·3	741·3	Wadi Abuksheib (mouth)	do.
„ 8	7.45 a.m.	20·6	740·8	do.	Clear.
„ „	11.— a.m.	22·8	741·0	do.	Clear, N.E. breeze.
„ „	2.30 p.m.	23·0	..	Gebel Moghtut (550 metres above valley)	Some clouds.
„ „	6.40 p.m.	22·5	726·4	Wadi Ma'in	Still, clear.
„ 9	7.30 a.m.	22·2	729·3	do.	Strong wind, clear.
„ „	11.— a.m.	21·7	..	Gebel Ma'in (750 metres above valley)	Clear, still.
„ „	1.30 p.m.	22·7	..	do.	N.E. light breeze, clear sky.
„ „	7.30 p.m.	22·2	..	Wadi Ma'in	Gusts of wind.
„ 10	1.20 p.m.	27·8	..	Gebel Um El Wejera (400 metres above valley)	do.
„ „	2.— p.m.	28·3	..	....	Clear, faint N.E. breeze.
„ „	7.— p.m.	24·4	718	Wadi Um Athaga	Still, clear.
„ „	9.30 p.m.	22·2	717·8	do.	do.
„ 11	7.30 a.m.	25	716·5	do.	do.
„ „	12.30 p.m.	25·3	..	Gebel Lij (600 m. above valley)	do.
„ „	3.30 p.m.	24·6	..	do.	Still, little cloud.
„ „	8.— p.m.	26·8	716·4	Wadi Um Athaga	Clear, still.
„ „	10.— p.m.	23·9	716·9	do.	Clear, gusts of wind from N.
„ 12	7.— a.m.	26·3	716·9	do.	Still, cloudy.
„ „	8.— a.m.	26·1	717·4	do.	Still, little cloudy.
„ „	7.30 p.m.	21·1	700·0	Wadi Um Harag	Still, clear.
„ 13	6.30 a.m.	20·0	698·9	do.	do.
„ „	8.— a.m.	21·7	699·4	do.	do.
„ „	12.— p.m.	23·3	..	Gebel Zaraga (over 1000 met. above camp)	N.E. light breeze.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 13	3.— p.m.	21·8	..	....	Clear, few clouds in west.
„ „	4.— p.m.	20	..	....	Light breeze.
„ „	8.— p.m.	21·7	698·6	Wadi Um Harag	Still, clear.
„ 14	12.— p.m.	31·3	697·3	....	do.
„ „	4.— p.m.	31·1	..	Station, 200 m. above valley	do.
„ „	8.— p.m.	25·6	722·3	Wadi Um Shoka	do.
„ „	10.— p.m.	26·1	722·5	do.	do.
„ 15	7.— a.m.	26·7	..	do.	do.
„ „	12.— p.m.	24·7	..	Gebel Um Shoka El Kebir (900 metres)	do.
„ „	3.— p.m.	25	..	do.	do.
„ „	8.— p.m.	28·3	713·8	Wadi Um Shoka	Still, clear.
„ 16	..	..	..	....	Same as above.
„ 17	11.— a.m.	31·3	..	Stations II and III Sheet 16	Still, clear.
„ „	1.— p.m.	32·2	..		do.
„ 18	10.30 a.m.	30·5	714·4	Wadi Um Shoka	do.
„ „	12.— p.m.	31·7	..	Gebel Um Shoka (500 m.)	Light breez , east.
„ „	1.— p.m.	30·6	..	do.	East breeze, clear.
„ „	3.— p.m.	30·0	..	do.	Some clouds coming up.
„ „	9.30 p.m.	25·3	713·1	Wadi Um Shoka	Still, clear.
„ 19	6.30 a.m.	26·1	713·3	do.	Clear, windy.
„ „	7.40 a.m.	28·9	714	do.	Clear.
„ „	10.— a.m.	31·1	..	....	East breeze, some clouds.
„ „	3.— p.m.	29·2	..	Gebel Jeraimda (400 metres)	Few clouds.
„ „	8.— p.m.	25·4	739·7	Wadi Abuksheib	Still, clear.
„ 20	7.— a.m.	30·2	740·5	do.	do.
„ „	9.30 a.m.	34	..	Sandstone in Wadi Nasb (near 100 metres)	Clear, light breeze from E. to N.E.
„ „	1.— p.m.	33·9	..	Station (400 metres)	Light East breeze.
„ „	3.30 p.m.	31·1	..	do.	Nearly clear.
„ „	8.— p.m.	28·9	734·7	Wadi Nasb (Dahab)	Still, clear.
„ 21	8.20 a.m.	33·9	736·4	do.	do.
„ „	10.— a.m.	37·2	..	do.	do.
„ „	12.30 p.m,	39·5	..	do.	do.
„ „	1.— p.m.	39·5	..	do.	East breeze.
„ „	2.— p.m.	37·2	735·3	do.	....
„ „	8.— p.m.	30·0	735·8	do.	Clear, windy.
„ 22	6.— a.m.	25·3	736·4	....	Still, clear.
„ „	7.— a.m.	30·0	736·8	....	do.
„ „	9.45 a.m.	32·2	..	Station (over 300 metres)	do.
„ „	12.— p.m.	33·3	..	do.	Few flaky clouds.
„ „	4.— p.m.	30·6	..	Station (600 metres)	Clear, still. Windy Night.
„ 23	6.— a.m.	25·6	736·8	Wadi Nasb	Clear, windy.
„ „	1.— p.m.	35·8	..	Gebel Um Malaga (700 m.)	Slight haze.

* Heights given above valley level.

Observations for April, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
April 23	2.— p.m.	33·6	..	Gebel Um Malaga (700 m.)	Still, clear sky.
„ „	4.— p.m.	32·2	..	do.	do.
„ „	8.30 p.m.	28·6	727·4	Wadi Nasb	do.
„ 24	7.— a.m.	24·4	727·2	do.	do.
„ „	12.— p.m.	36·1	..	Gebel Hammam (500 metres)	do.
„ „	4.— p.m.	34	..	do.	do.
„ „	8.30 p.m.	30·6	722·8	Wadi Nasb	Strong N.E. wind.
„ 25	6.30 a.m.	23·3	723·7	do.	Windy, clear.
„ „	10.— a.m.	30·6	..	Station 11, Sheet 16	Clear, light N. breeze.
„ „	2.30 p.m.	33·3	..	do.	....
„ „	Evening	28·9	..	Wadi Nasb	Windy.
„ 26	6.30 a.m.	21·7	722·8	do.	Still, clear.
„ „	7.— a.m.	29·4	723·3	do.	Still, clear, clouding.
„ „	4.— p.m.	25·6	..	Gebel Gurna (700 metres)	Clouded, but not entirely.
„ „	7.— p.m.	26·1	706·8	Wadi Nasb	Still, heavily clouded.
„ 27	6.30 a.m.	23·7	709·09	Wadi Nasb (E. bend) and Wadi Thaiyib Tissim	Still, quite clouded over.
„ „	2.30 p.m.	32·2	..	Gebel Thaiyib Tissim (450)	Clouds clearing away. S.E. breeze.
„ „	7.30 p.m.	28·6	706·6	Wadi Nasb (as above)	Still, nearly clear.
„ 28	1.— p.m.	29·4	..	Stations Gebel Sadagiya,	S.E. breeze, clear
„ „	3.— p.m.	28·3	..	etc... (500 metres)	sky.
„ „	9.— p.m.	25·4	695·8	Wadi Nasb and Wadi Meer	Still, clear.
„ 29	7.30 a.m.	30·0	695·8	do.	do.
„ „	11.— a.m.	30·6	..	Gebel Rubha (600 metres)	do.
„ „	1.— p.m.	30·8	..	do. (higher peak)	West breeze.
„ „	7.30 p.m.	27·7	694·8	Wadi Nasb and Wadi Mir	Still, clear.
„ 30	7.30 a.m.	21·7	696·9	do.	Clear, breeze.
„ „	10.45 a.m.	22·2	..	Gebel Adiebat (800 metres)	Clear, N. breeze.
„ „	12.40 p.m.	24·7	..	do.	....
„ „	3.30 p.m.	22·6	695·8	Wadi Nasb and Wadi Meer	Still, clear, hazy in evening.

* Heights given above valley level.

The Maximum recorded for the month of April was 39°·5 C. (103 F.) between 12.30 and 1 p.m. on the 21st in Wadi Nasb (Dahab), the Minimum 17°·8 C. at 6.30 a.m. on the 5th at Dahab.

The Morning Averages (31 readings)=23°·5 C., the Maximum being 33.9 at 8.20 a.m. on the 21st, and 30.2 at 7 a.m. on the 20th, in Wadi Abuksheib, the Minimum 17°·8 C.

The Afternoon Averages practically are those for heights of 1000 metres above sea-level, or 500 above valley-level=24°·6 C., the Maximum record was 39°·5 C., the minimum 19°·4 C. on the 5th, 4 p.m. (hills west of Dahab).

The Evening Average (mainly between 7 and 8 p.m.)=24.8 C. Maximum 30°·6 at 8.30 p.m., 24th, Wadi Nasb. Minimum 18°·3 C. at 7.30 p.m. on the 1st at mouth of Wadi Gnai El Atshan. The morning averages alone are therefore useful for comparison with previous months.

Rain was entirely absent, heavy cloud also being rare, 7th, 8th, 12th, 19th, 26th and 27th, being nearly the only records. The Wind record, on the contrary, is high, during the first seven days, which were spent on the Gulf of Akaba, there being practically no cessation day or night, it throughout blowing from the N.E., or down the Gulf. For fifteen days breezes were noted, mostly light N.E. and in the afternoon, but on the night of the 22nd and evening of the 24th, the force was much greater. Owing to the prevalent direction of the air currents, their movements are much more noticeable in the north and south rifts, such as the Gulf of Akaba and the parallel valleys in East Sinai, than in the Transverse Valleys.

April may be said to have marked the distinct change to summer conditions, temperatures above 30° C. being recorded three times in the morning, 11 times afternoon, twice in the later evening, about eight.

Observations for May, 1899.

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899.					
May 2	7.30 a.m.	21·1	697·9	Wadi Nasb and Wadi Mir	Clear, still.
„ „	10.10 a.m.	23·3	690·5	North bend of Nasb	Clear, then N. breeze (3.30).
„ 3	7.— a.m.	22·8	710·1	Wadi Thaiyib Tissim and Nasb	Still, clear.
„ „	11.15 a.m.	27·3	..	Wadi Nasb	N.E. breeze, clear.
„ „	1.— p.m.	28·9	..	do.	Clear sky,
„ „	4.30 p.m.	25·6	..	do.	N.E. breeze, clear sky
„ 4	1.— p.m.	28·3	..	Station (300 metres)	Still, clear.
„ „	4.— p.m.	26·4	..	do.	N.E. breeze, clear sky. light haze.
„ „	7.40 p.m.	21·7	696·2	Plain of Barga	Still, clear.
„ 5	7.20 a.m.	18·3	697·3	do.	do.
„ „	11.— a.m.	23·3	..	Gebel Um Ushtan (300 m.)	N. breeze, clear.
„ „	1.— p.m.	26·1	..	do.	Clear.
„ „	4.30 p.m.	23·7	..	do.	N. breeze, clear.
„ 6	7.40 a.m.	21·7	702·8	Wadi Hammam	Clear, still.
„ „	12.15 p.m.	28·3	..	Gebel El Araish (250 metres)	Clear, N. breeze.
„ „	2.30 p.m.	29·4	..	do.	do.
„ „	7.— p.m.	24·4	700·4	Wadi Hammam	Still, clear.
„ 7	6.30 a.m.	17·8	700·8	do.	do.
„ „	7.20 a.m.	22·2	701·5	do.	do.
„ „	12.— p.m.	25·6	..	Gebel Barga (300 metres)	Moderate N. breeze.
„ „	1.30 p.m.	27·2	..	do.	do.
„ „	4.30 p.m.	26·1	..	do.	do.
„ „	7.30 p.m.	23·3	694·5	Plain of Barga	North breeze, clear.

* Heights given above valley level.

Observations for May, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
May 7	9.— p.m.	22·2	695·4	Plain of Barga.	Slight breeze, clear.
„ 8	6.20 a.m.	17·2	694·2	do.	Clear, still.
„ „	7.— a.m.	23·3	694·8	do.	do.
„ „	10.— a.m.	27·8	..	Station (200 metres).	N. breeze, clear.
„ „	11.30 a.m.	29·7	..	do.	Few thin clouds coming from west.
„ „	2.— p.m.	35·3	..	Gebel Um Raiyig (200).	....
„ „	5.— p.m.	31·1	..	do.	....
„ „	9.30 p.m.	23	691·9	Wadi Somra	Still, clear.
„ 9	6.20 a.m.	20	692·0	do.	do.
„ „	7.20 a.m.	27·2	693·0	do.	do.
„ „	9.45 a.m.	33·9	..	Low Stations	Thin clouds.
„ „	1.— p.m.	33·9	..		
„ „	3.40 p.m.	32·8	..		Still, cloudy.
„ „	7.30 p.m.	28·3	687·9	Wadi Amutamir	....
„ 10	7.30 a.m.	27·2	669·4	do.	Clear, still.
„ „	11.— a.m.	33·0	..	Station (150 metres)	Some thin clouds, light North breeze.
„ „	3.— p.m.	30·6	..	Gebel Gunna (400 metres)	North wind.
„ 11	8.— a.m.	25·6	686·6	Plain at foot of Gunna	....
„ „	9.40 a.m.	31·7	..	....	N. breeze.
„ „	2.— p.m.	33·9	..	....	N. breeze, sky full of white fleeces.
„ „	5.30 p.m.	29·4	..	....	Strong N. wind, with stormy clouds.
„ „	9.— p.m.	27·5	688·4	Wadi Hejaj	N. wind, clouds.
„ 12	7.30 a.m.	27·2	688·4	Near Ain El Hudera	Still, clear.
„ „	11.40 a.m.	34·2	..	Stations 200 metres above valley Gebel Hudera	N.E. wind, clear.
„ „	12.30 p.m.	36·4	..		....
„ „	1.30 p.m.	33·9	..		N. E. breezes, white fleeces.
„ „	3.30 p.m.	32·8	..		White clouds. Heavy clouds at 6 p.m.
„ „	7.— p.m.	27·2	688·2	Near Ain El Hudera	Cloudy.
„ 13	11.30 a.m.	36·1	..	Ain El Hudera	N.E. breeze, white clouds.
„ „	12.30 p.m.	35·6	..	do.	Strong West wind, heavy clouds and showers.
„ 14	6.— a.m.	22·8	693·2	Wadi Ejjibi	Clear, still.
„ „	7.30 a.m.	27·8	..	do.	do.
„ „	10.30 a.m.	33·3	..	Low Stations	do.
„ „	6.— p.m.	31·1	..		Windy.
„ „	9.— p.m.	27·9	695·0	Wadi Um Rowa	do.
„ 15	7.30 p.m.	27	707·6	Junction of Wadi Raib and Wadi Abu Lassaf	N.W. wind in day. Little wind.
„ 16	7.30 a.m.	24·7	708·0	do.	Still, clear.
„ „	11.30 a.m.	29·3	..	Gebel Kharaza (400 metres)	do.
„ „	1.30 p.m.	30·6	..	do.	Still, clear.

* Heights given above valley level.

Observations for May, 1899 (*continued*).

Date	Time	Temperature Centigrade	Pressure Millimetres	LOCALITY	REMARKS
1899					
May 17	Evening	29·7	..	Wadis Raib and Abu Somra	West wind, clear.
„ „	10.30 a.m.	25·6	714·8	do.	N. breeze, clear.
„ „	12.— p.m.	26·4	..	Gebel Abu Somra (500 metres)	N. breeze, clear.
„ „	1.— p.m.	29·4	..		do.
„ „	3.30 p.m.	27·2	..		Still, clear.
„ „	7.— p.m.	27·2	713·4	Wadi Abu Somra and Wadi Raib	do.
„ 18	7.30 a.m.	24·8	724·7	Wadi Kharaza	Clear, still, all day.
„ 19	7.30 a.m.	28·3	..	do.	Still, clear.
„ „	11.30 a.m.	34·4	..	Gebel Abu Habba (500 metres), and another Station	N. E. breeze.
„ „	1.— p.m.	32·8	..		....
„ „	3.— p.m.	33·2	..		Still, clear in evening.
„ 20	11.— a.m.	12·4	..	Top of Mt. Sinai	....
„ 26	11.— a.m.	25·8	750·2	Tor camp	Clear, still.
„ „	11.45 p.m.	25·3	749·3	do.	N.W. breeze.
„ 27	9.— a.m.	25·3	750·6	do.	....
„ „	5.30 p.m.	29·2	748·8	do.	Stiff N.W. breeze.
„ 28	9.30 a.m.	25·8	751·2	do.	....
„ „	10.— p.m.	25·3	749·1	do.	....

* Heights given above valley level.

For the first nineteen days of May (excluding 1st) the *Maximum* record was 36°·4 C. at 12.30 p.m. on the 12th at Ain El Hudera, the *Minimum* 17°·2 C. at 6.20 a.m. on the 8th (plain of Barga).

Average for *Morning* (12 readings)=22°·6 C. *Maximum* 28°·3 C. at 7.30 a.m. on the 19th (in Wadi Raib). *Minimum* 17°·2 as above. The average is too high, as this month there was considerable difference between readings made at 6 and 7 a.m. respectively.

Afternoon Average (15 readings)=31°·9 C. *Maximum* 36°·4 C. as above. *Minimum*= 26°·1 C. at 1 p.m. on Gebel Um Ushtan.

Evening Average=27°·1 C. (11 readings). *Maximum* 37°·1 C. at 5 p.m. on 8th on Gebel Um Raiyig, and 6 p.m. on the 14th on plateau above Wadi Um Rowa. *Minimum* 21°·7 C. on the 4th in the plain of Barga. Only 12°·4 C. was noted on the summit of Sinai on the 22nd. Showers fell on the 13th, and between the 10th and 15th several storms were seen to pass over Sinai and the Abu Mesûd district.

In the afternoons N.E. breezes were common, accompanied by thin clouds; after the 15th, west winds began to be noted, and at Tor these were blowing with great regularity. Heavy clouds were only recorded from the 11th to the 13th.

APPENDIX II.

The writer, acting under the advice of botanical friends, had originally proposed making the appended list the basis for a critically studied florula of the Sinai peninsula. Owing to the pressure of other work, this aim has to be abandoned, and the list, as originally prepared, is inserted without amendment, in the hopes that it may prove of some use to those working at the wider question of plant-distribution. On it are based any of the wider conclusions drawn in the botanical section, which for the same reasons as those above given, has also to be published in its present form.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA.

Natural Order	Plant	Arabic Name	Distribution	Collection
I.—PAPAVERACEÆ.				
1. *Papaveraceæ.*	*Papaver Decaisnei*, Hochst. and Steud.	....	Wadi Tarfa.	Kneucker Coll.
2. do.	*Rœmeria dodecandra*, (Forsk.) Fedde.	....	In valleys and plains near Sinai.	Do.
3. do.	*Do.* var. *pinnatifida* (Boiv.) Boiss.	....	Gebel Katharina at 2,450 met.	Do.
4. do.	*Glaucium arabicum*, Fresen.	No'man.	Wadi Tarfa (1,100 metres).	Do. and Ord. Surv.
5. do.	*Glaucium grandiflorum*, Boiss. et Huet.	....	Near Sinai convent (1,500 m.)	Kneucker Coll.
6. do.	*Hypecoum pendulum*, L.	Salîhh.	Ditto.	Do. P.F.
II.—FUMARIACEÆ.				
7. *Fumariaceæ.*	*Fumaria parviflora*, Lam.	....	One specimen Gebel Katharina, 1800-1900 metres.	Do.
III.—CRUCIFERÆ.				
8. *Cruciferæ*	*Morettia philœana* (Del.), D.C.	....	Qa'a plain.	Do.
9. do.	*Morettia canescens*, Boiss.	Rakhmi.	Sinai generally.	Do. and Ord. Surv.
10. do.	*Morettia parviflora*, Boiss.	....	Once only, between Feirân and Maghara.	Kneucker Coll.

NOTE.—K.C.=Kneucker Coll. P.F.=Post's Flora. Ord. Surv.=Ordnance Survey.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA— *(continued)*.

Natural Order	Plant	Arabic Name	Distribution	Collection	
III.—CRUCIFERÆ (*cont.*)					
11. *Cruciferæ.*	*Matthiola arabica*, Boiss.	Ghomghom.	Sinai generally.	Hume Coll. K.C.	
12. do.	*Matthiola livida* (Del.), Boiss.	....	Ditto.	Kneucker Coll.	
13. do.	*Eremobium ægyptiacum*, (Spreng.)	....	In sandy places. Wadis Werdan and Gharandel.	Kneucker Coll.,	P.F.
14. do.	*Eremobium lineare* (Del.), Boiss.	Samih or Qabah.	Feiran Oasis, in sandy places.	Do.	P.F.
15. do.	*Farsetia ægyptiaca*, Turr.	....	Especially between Wadis Werdan and Gharandel.	Do.	O.S.
16. do.	*Arabis auriculata*, Lam.	....	Small plant growing under granite boulders (Gebel Katharina, etc.).	Do.	
17. do.	*Sisymbrium Schimperi*, Boiss.	....	Jebels Musa and Katharina..	Do.	P.F.
18. do.	*Sisymbrium Kneuckeri*, Bornm.	....	Foot of Gebel Katharina, 1800-1850 m.	Do.	
19. do.	*Sisymbrium* f. *aprica.*	....	Foot of Gebel Serbal, 1100-1400 m.	Do.	
20. do.	*Sisymbrium rigidulum*, Decsn.	Salih	Southwest and Central Sinai, 400-1500 m.	Do.	P.F.
21. do.	*Sisymbrium erysimoides*, Dsf.	Thuwwat	Feiran Oasis and foot of Serbal (600-750 m.).	Do.	P.F.
22. do.	*Sisymbrium iris*, L.	....	Wadi Tarfa and plain of Er Raha.	Do.	
23. do.	*Malcolmia africana*, (L.) R.Br.	....	Various places from 600-2450 metres.	Do.	
24. do.	*Alyssum marginatum*, Steud.	....	Near Sinai Convent 1500 m.	Do.	
25. do.	*Clypeola microcarpa*, Moris.	....	Stony places, Sinai.	Do.	P.F.
26. do.	*Clypeola jonthlaspi*, L.	....	Hills and sandy places.	Post's flora.	
27 do.	*Notoceras Canariensis*, R.Br.	....	From Serbal to Wadi Shellal, 200-750 m.	Kneucker Coll.	
28. do.	*Isatis microcarpa*, J. Gay.	....	Wadi Tarfa 1100-1200 m. and Wadi Seba'iaa.	Do.	P.F.
29. do.	*Moricandia Sinaica*, Boiss.	Khusian el Jemel or Yahag.	Wadi Isla, 200-500 m. also in Wadi El Sheikh.	Do.	P.F.
30. do.	*Moricandia dumosa*, Boiss.	Hhamimah.	....	Post's flora.	
31. do.	*Moricandia clavata*, Boiss. et	....	....	Do.	

				especially Wadi Letih.	Colls., K.C.	
33.	do.	*Diplotaxis acris*, Forsk.	Shuqaiyar.	Wadi El Sheikh.	Kneucker Coll.	
34.	do.	*Brassica Tournefortii*, Gou.	....	Cultivated. Wadi Feiran 600 metres.	Do.	
35.	do.	*Savignya Ægyptiaca*, D.C.	Hhalawah.	Wadi Isla and Gharandel.	Do.	P.F.
36.	do.	*Zilla myagroides*, Forsk.	Bsilla.	Ubiquitous.	Hume Coll.	K.C.
37.	do.	*Anastatica hierochuntina*, L.	....	On coral reefs between Nebk and Sherm.	Do.	
38.	do.	*Carrichthera vellæ*, D.C.	....	....	Post's flora.	
39.	do.	*Kœniga arabica*, Boiss.	Dhahhiyan.	....	Do.	
40.	do.	*Schimpera arabica*, Hochst et St.	Es Sufeira.	....	Do.	
41.	do.	*Enarthrocarpus strangulatus*, Boiss.	Shilwat or Yasanid.	....	Do.	
42.	do.	*Hussonia uncata*, Boiss.	....	....	Do.	
43.	do.	*Schouwia arabica*, D.C.	Nam-nam	....	Hume Coll.	
IV.—CAPPARIDACEÆ.						
44.	*Capparidaceæ*,	*Cleome arabica*, L.	Janinah Zifrah or Shajarat wahhsh (P.F.)	(O.S.) also Um Rumail.	Kneucker, Coll.	O.S.
45.	do.	*Cleome trinervia*, Fresen.	....	Wadi Isla.	Do.	O.S.
46.	do.	*Cleome brachycarpa*, Val.	Berberan.	Sinai near Red Sea.	Post's flora.	
47.	do.	*Cleome droserifolia*, Del.	? Sommu, Rihh-el-bard (P.F.)	Common in south-east Sinai.	Hume Coll.	
48.	do.	*Cleome chrysantha*, Den.	Sufeir atan.	Invading southern form.	Ord. Survey.	
49.	do.	*Capparis spinosa*, L.	Lassaf.	In mountain ravines.	Hume Coll.	
50.	do.	*Mœrua uniflora*, Vahl.	....	....	Post's flora.	
V.—RESEDACEÆ.						
51.	*Resedaceæ*.	*Ochradenus baccatus*, Del.	Gurdi.	Common in the mountain valleys.	Hume Coll.	K.C.
52.	do.	*Reseda propinqua*, R.Br.	....	Wadi Aleyat (Serbal), 650-755 m.	Kneucker Coll.	P.F.
53.	do.	*Reseda arabica*, Boiss.	....	Wadis Werdan and Gharandel.	Do.	P.F.
54.	do.	*Reseda pruinosa*, Del.	Kazum.	Wadi Tarfa and El Sheikh.	Do.	P.F.
55.	do.	*Reseda stenastachya*, Boiss.	....	Sinaitic valleys.	Post's flora,	
56.	do.	*Reseda muricata*, Presl.	....	....	Do.	
57.	do.	*Caylusea canescens*, (L.) S. Hil.	....	Ubiquitous.	Kneucker Coll.	P.F.
58.	do.	*Oligomeris subulata*, Del.	....	....	Post's flora.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plants.	Arabic Names	Distribution.	Collection.
VI. CISTACEÆ.				
59. *Cistacea*.	*Helianthemum rentosum*, Boiss.	Ra'r.	Wadi el Akhdar.	Barron Coll. K.C.
60. do.	*Helianthemum kahiricum*, Del.	Girsum	Between Wadi Werdan and Gharandel.	Kneucker Coll. O.S.
61. do.	*Helianthemum Sancti Antonii*, Schweinf.	....	Foot of Serbal, 1100-1400. m.	Do.
62. do.	*Helianthemum Lippi*, (L.) Boiss. Y. *micranthum* Boiss.	....	Stony places.	Do.
63. do.	*Helianthemum vesicarium*, Boiss.	....	....	Post's flora.
VII.—SILENACEÆ.				
64. *Silenacea*.	*Tunica arabica*, Boiss.	....	Wadi Aleyat (Serbal) 650-750 m.	Kneucker Coll.
65. do.	*Dianthus Libanotis*, Labille.	....	Mount St. Katharina.	Post's flora.
66. do.	*Dianthus sinaicus*, Boiss.	Sammah.	Rocks at base of Sinai.	Do.
67. do.	*Gypsophila Rokejeka*, Del.	Sirr.	Dry places and high mountain plateaux.	Hume Coll.
68. do.	*Gypsophila elegans*, M.B.	....	Between Wadis Werdan and Gharandel.	Kneucker Coll. P.F.
69. do.	*Gypsophila hirsuta*, var. *alpina*, Boiss.	....	Gebel Katharina.	Post's flora.
70. do.	*Silene eremophila*, Bienert.	....	Sandy and gravelly places: Wadi Tarfa, etc.	Kneucker Coll.
	Silene odontopetala, Fenzl.	....	....	....
	Silene congesta, Boiss.	Mt St Katharina.	....	....
71. do.	*Silene apetala*, Willd.	....	Feiran Oasis.	Kneucker Coll.
	Silene conoidea, L.	....	....	Boissier.
72. do.	*Silene villosa*, Forsk.	Nimwar Atani, etc.	Debbet er Ramleh.	Barron Coll.
	Silene schimperiana, Boiss.	....	....	Boissier Coll.
73. do.	*Silene arabica*, Boiss.	....	Sands, Sinai.	Post's Flora.
	Silene oliveriana, Otth.	....	Arabia Petræa.	Boissier Coll.
74. do.	*Silene bipartita*, var, *stenophylla* Boiss.	....	....	Do.
75. do.				

	VIII.—ALSINEÆ.					
77.	*Alsineæ.*	*Alsine brevis*, Boiss.	....	Er Raha plain.	Kneucker Coll.	P.F.
78.	do.	*Alsine picta*, var. *sinaica*, Boiss.	Quleiqalah.	Sinai valleys.	Do.	P.F.
79.	do.	*Holosteum liniflorum*, Stev.	....	Do.	Do.	P.F.
80.	do.	*Cerastium viscosum*, L.	....	Feiran Oasis.	Do.	
81.	do.	*Spergularia diandra* (Guss.) Boiss.	....	Do.	Do.	
	IX.—PARONYCHIACEÆ.					
82.	*Paronychiaceæ.*	*Robbairea prostrata* (Forsk.), Boiss.	Enjiadeh and numerous other names.	Ubiquitous.	Hume Coll.	K.C.
83.	do.	*Polycarpæa fragilis*, Del.	Qumeilah or Makk.	Widely distributed.	Kneucker Coll.	P.F.
84.	do.	*Herniaria hemistemon*, Gay.	Um Libbaideh.	Wadi Gharandel and Wadi Werdan.	Do.	P.F.
85.	do.	*Paronychia lenticulata*, (Forsk.) Aschers. and Schweinf.	....	Between Wadi Feiran and Maghara.	Do.	
86.	do.	*Paronychia sinaica*, Fresen.	....	Sinai Monastery.	Do.	P.F.
87.	do.	*Paronychia desertorum*, Boiss.	Rukhaimah or Libbeit.	On sands.	Post's flora.	
88.	do.	*Gymnocarpus fruticosum*, Pers.	....	Wadi Isla and foot of Serbal, 1100-1400 m.	Kneucker Coll.	
89.	do.	? *Gymnocarpus decander.*	Djeradeh.	Hill shrub in Um Zeinig and Gnai.	Hume Coll.	
90.	do.	*Pteranthus echinatus*, Desf.	....	Foot of Serbal.	Kneucker Coll.	P.F.
91.	do.	*Cometes abyssinica*, R. Br.	....	Wadi Isla (Southern Sinai).	Do.	P.F.
92.	do.	*Polycarpon arabicum*, Boiss.	....	....	Post's flora.	
93.	do.	*Polycarpon succulentum*, Del.	....	....	Do.	
94.	do.	*Sclerocephalus arabicus*, Boiss.	....	....	Do.	
	X.—MOLLUGINEÆ.					
95.	*Molluginæ.*	*Telephium sphærospermum*, Boiss.	....	Wadi Sheikh and Wadi Hebran.	Do.	
96.	do.	*Glinus*, sp.	Lepetha.	....	Hume Coll.	
	XI.—TAMARISCINEÆ.					
97.	do.	*Reaumuria hirtella*, Jaub. et sp.	Mellâhh.	Wadi Gharandel.	Kneucker Coll.	P.F.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.	
XI.—TAMARISCINEÆ—(*cont.*)					
98. *Tamariscineæ.*	*Reaumuria palæstina*, Boiss.	....	....	Post's flora.	
	Tamarix tetragyna, Ehrenb.	....	....	Boissier Coll.	
99. do.	*Tamarix mannifera*, Ehr.	Tarfa.	Ubiquitous.	Ord. Serv.	
100. do.	*Tamarix articulata*, Vahl.	....	....	Do.	
XII.—HYPERICINEÆ					
101. *Hypericineæ.*	*Hypericum sinaicum*, Hochst.	....	Moist rocks.	Post's flora.	
XIII.—MALVACEÆ.					
102. *Malvaceæ.*	*Althæa Ludwigii*, L.	....	....	Do.	
103. do.	*Alcea striata*, D.C.	Khutmi.	Valley of Rephidim.	Do.	
104. do.	*Malva ægyptia*, L.	Khubbaizeh.	....	Do.	
105. do.	*Malva rotundifolia*, L.	....	Wadi Letih.	Hume Coll.	
106. do.	*Malva parviflora*, L.	....	Near Sinai Convent and Wadi Feiran.	Kneucker Coll.	
107. do.	*Sida rhombifolia*, L.	....	....	Post's flora.	
108. do.	*Abutilon fruticosum*, Guill. et Perr.	....	On rocks.	Do.	
109. do.	*Hibiscus ovalifolius*, Vahl.	Khutmi.	Do.	Do.	
XIV.—TILIACEÆ.					
110.—*Tiliaceæ.*	*Grewia populifolia*, Vahl.	....	....	Do.	
XV.—GERANIACEÆ.					
111. *Geraniaceæ.*	*Erodium cicutarium*, L.	....	....	Kneucker Coll.	O.S.
112. do.	*Erodium laciniatum*, Cav.	....	Wadi Sig. Er Raha Plain.	Barron Coll. Kneucker Coll.	
113. do.	*Erodium laciniatum*, var. *pulverulenta*, (Desf.) Boiss.	Ujreiyat-el-Ghazal.	Near Sinai Convent and Feiran Oasis.	Do.	P.F.
114. do.	*Erodium glaucophyllum*, Ait.	Kabshiyah, etc.	Between Wadis Gharandel and Werdan.	Do.	P.F.
115. do.	*Erodium bryoniæfolium*, Boiss.	Dehamin or Murghit.	Er Raha Plain and Wadi El Sheikh.	Do.	P.F.
116.					

120a.	do.	*Tribulus alatus*, Del.	Dreisi.	....	Hume Coll.	
121.	do.	*Fagonia glutinosa*, Del.	Shika'ah or Medahin.	Between Wadis Gharandel and Werdan.	Kneucker Coll.	P.F.
122.	do.	*Fagonia myriacantha*, Boiss.	....	Wadis Isla, Tarfa.	Do.	P.F.
123.	do.	*Fagonia mollis*, Del.	....	Wadi Isla.	Do.	O.S.
124.	do.	*Fagonia sinaica*, Boiss.	....	Feiran Oasis.	Do.	P.F.
125.	do.	*Fagonia cretica*, L.	....	....	Post's flora.	
126.	do.	*Fagonia Bruguieri*, D.C.	....	....	Do.	
127.	do.	*Fagonia arabica*, L.	Aqul.	....	Ord. Surv.	
128.	do.	*Fagonia cistoides*, Del.	Oward.	....	Do.	
129.	do.	*Zygophyllum simplex*, L.	....	Feiran Oasis.	Kneucker Coll.	O.S.
130.	do.	*Zygophyllum album*, L.	....	Near sea-coast from Tor to Wadi Werdan.	Do.	
131.	do.	*Zygophyllum coccineum*.	Ratreet.	Ras Mohammed.	Hume Coll.	
132.	do.	*Peganum harmala*, L.	Haremlan.	Between Wadis Tarfa and Rutig.	Kneucker Coll.	
133.	do.	*Nitraria tridentata*, Desf.	Gharqad.	Common in large valleys and on seashore.	Hume Coll.	K.C.
134.	do.	*Seetzenia orientalis*, Dec.	Habein.	....	Post's flora.	
XVII.—RUTACEÆ.						
135.	*Rutaceæ*.	*Haplophyllum tuberculatum* (Forsk).	Mugennineh.	....	Ord. Surv.	
XVIII.—RHAMNACEÆ.						
136.	*Rhamnaceæ*.	*Zizyphus Spina-Christi*, (L.) β. *inermis*, Boiss.	Sidri.	Feiran Oasis and Wadi Kyd.	Hume Coll.	K.C.
XIX.—MORINGEÆ.						
137.	*Moringeæ*.	*Moringa aptera*, Gaertn.	Ban.	Wadi Hebran.	Barron Coll.	
XX.—LEGUMINOSÆ.						
138.	*Leguminosæ*.	*Lotonomis leobordea*, Benth.	....	Lower Wadi Isla and Er Raha Plain.	Kneucker Coll.	
139.	do.	*Lotononis dichotoma*, Del.	Hhurbut.	....	Post's flora.	
140.	do.	*Lotononis* do., var. *persica*, Post.	....	....	Do.	
141.	do.	*Retama roetam*, Forsk.	Retem.	Common in North Sinai, rare in South portion.	Hume Coll.	K.C.
142.	do.	*Trigonella stellata*, Forsk.	....	....	Barron Coll.	K.C.
143.	do.	*Trigonella arabica*, Del.	....	....	Do.	
144.	do.	*Trigonella microscarpa*, Fresen.	G'rieh.	....	Ord. Surv. Coll.	
145.	do.	*Melilotus Indica*, All.	....	Moist places in Feiran Oasis.	Kneucker Coll.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XX.—LEGUMINOSÆ.—(*cont*).				
146. *Leguminosæ.*	*Lotus arabicus*, L.	Gathbi.	Wadi Tarfa, etc.	Hume Coll. K.C.
147. do.	*Lotus glinoides*, Del.	....	....	Post's flora.
148. do.	*Psoralea bituminosa*, L.	Samar.	....	Ord. Surv. Coll.
149. do.	*Psoralea Palæstina*, L.	....	Wadi Tarfa.	Kneucker Coll.
150. do.	*Colutea Haleppica*, Lam.	Qasnur.	Foot of Gebel Serbal.	Do. P.F.
151. do.	*Astragalus prolixus* Sieb.	....	Lower Wadi Isla.	Do.
152. do.	*Astragalus tribuloides* Del.	Rukhaimi or Qudad.	Sandy places in Wadi Tarfa, Sinai, and foot of Serbal.	Do. P.F.
153. do.	*Astragalus corrugatus*, Bert.	....	Lower Wadi El Sheikh.	Do. P.F.
154. do.	*Astragalus* do., var. *brevipes*, Post.	....	Wadi Feiran.	Post's flora.
155. do.	*Astragalus bombycinus*, Boiss.	Durreis or Khansarat el Arus.	Fairly common.	Kneucker Coll. P.F.
156. do.	*Astragalus Fresenii*, Den.	Agfur.	Near Sinai Convent.	Do. P.F.
157. do.	*Astragalus sparsus*, Dec.	....	Among granite boulders at foot of Serbal.	Do. P.F.
158. do.	*Astragalus Sieberi*, D.C.	Qudad, etc.	Widely distributed.	Post's flora.
159. do.	*Astragalus echinus*, D.C.	....	On Gebel Musa (ab. 2100 m.) and Gebel Katherina (ab. 2450 m.).	Kneucker Coll.
160. do.	*Astragalus Forskhalei*.	Thimrah.	Near Foot of Serbal.	Do. P.F.
161. do.	*Astragalus Kneuckeri*, Freyn.	....	Between Wadi Tarfa and Gebel Musa.	Do.
162. do.	*Astragalus arabicus*, Ehr.	....	....	Post's flora.
163. do.	*Astragalus pseudostella*, Del.	..	....	Do.
164. do.	*Astragalus Schimperi*, Boiss.	Qureidun aswad.	....	Do.
165. do.	*Astragalus eremophilus*, Boiss.	Um-el-Qurein, etc.	....	Do.
166. do.	*Astragalus tenuirugis*, Boiss.	....	....	Do.
167. do.	*Astragalus Gyzensis*, Del.	Adham el Farah.	....	Do.
168. do.	*Astragalus hispidulus*, Astr.	....	....	Do.
169. do.	*Astragalus acinaciferus*, Boiss.	....	....	Ord. Surv. Coll.
170. do.	*Astragalus trigonus*, D.C.	....	....	Post's Flora.

175.	do.	*Cassia obovata*, Collad.	Senna.	Wadi Nasb and north of it.	Hume Coll. K.C.
176.	do.	*Cassia lanceolata*, Forsk.	Senna Sa'idi or Lisan-el-Asfur.	....	Post's Flora.
177.	do.	*Acacia tortilis*, Hayne.	Seyal.	Ubiquitous.	Kneucker Coll. P.F.
178.	do.	*Acacia Seyal*, Del.	Do.	Do.	Post's Flora.
179.	do.	*Acacia nilotica*, Del.	Sunt.	Southern Sinai.	Do.
180.	do.	*Crotalaria ægyptiaca*, Benth.	Natash.	Probably abundant in East Sinai.	Do.
181.	do.	*Argyrolobium uniflorum*.	....	....	Do.
182.	do.	*Ononis reclinata*, var. *minor*, Boiss.	....	....	Do.
183.	do.	*Medicago laciniata*, var. *brachyacantha*, Boiss.	....	....	Do.
184.	do.	*Medicago Aschersoniana*, Urban.	....	....	Do.
185.	do.	*Indigofera arabica*, Jaub. et Sp.	....	....	Do.
186.	do.	*Tephrosia purpura*, Pers.	....	....	Ord. Surv. Coll.
187.	do.	*Tephrosia apollinea*, Del.	Amyanah.	....	Post's Flora.
XXI.—ROSACEÆ.					
188.	*Rosaceæ*.	*Pirus communis*, L. f. *vergens ad cordatam* (*Desv.*)	....	Foot of Ras Safsaf.	Kneucker Coll.
189.	do.	*Neurada procumbens*, L.	....	Between Wadi Feiran and Maghara and Wadi Shellal.	Do. O.S.
190.	do.	*Rosa arabica*, Crep.	....	Mount St Katharine.	Post's Flora.
191.	do.	*Poterium verrucosum*, Spach.	Dhwaint-el-far or erbaiyan.	....	Ord. Surv. Coll.
192.	do.	*Cratægus aronia*, Bosc.	Za'rut.	....	Do.
		Cratægus sinaica, Boiss.	Za'rur.	....	Post's Flora.
XXII.—CRASSULACEÆ.					
193.	*Crassulaceæ*.	*Cotyledon umbilicus*, L.	....	....	Ord. Surv. Coll.
XXIII.—CUCURBITACEÆ.					
194.	*Cucurbitaceæ*.	*Cucumis prophetarum*, L.	Nafi'ah or Honedlai.	Ubiquitous.	Kneucker Coll. P.F.
195.	do.	*Citrullus colocynthis*, L.	Handal.	Do.	Do. O.S.
XXIV.—FICOIDEÆ.					
196.	*Ficoideæ*.	*Aizoon Canariense*, L.	....	Feiran Oasis.	Kneucker Coll.
197.	do.	*Aizoon hispanicum*, L.	Ghassul.	....	Post's Flora.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXV.—UMBELLIFERÆ.				
198. *Umbelliferæ.*	*Deverra tortuosa*, (Desf.) Boiss.	Qasuch.	Between Wadi Werdan and Wadi Gharandel.	Kneucker Coll. P.F.
199. do.	*Scandix pinnatifida*, Vent.	....	Round Sinai Convent in small plants.	Do.
200. do.	*Pycnocycla tomentosa*, Dec.	Sellam.	....	Ord. Surv. Coll.
201. do.	*Bupleurum linearifolium*, var. *Schimperianum*, Boiss.	....	....	Post's Flora.
202. do.	*Pimpinella cretica*, var. *arabica*, Boiss.	....	....	Do.
203. do.	*Ferula sinaica*, Boiss.	Shamar.	Um Shomer derives its name from this plant.	Do.
204. do.	*Zozimia absinthifolia*, Vent.	Kalth.	Base of Asafia (East Sinai).	Hume Coll.
XXVI.—RUBIACEÆ.				
205. *Rubiaceæ.*	*Oldenlandia Schimperi*, (Presl.) Boiss.	....	Wadi Isla and Er Raha Plain.	Kneucker Coll.
206. do.	*Crucianella membranacea*, Boiss.	....	Lower Wadi Sheikh.	Do. P.F.
207. do.	*Crucianella ciliata*, Lam.	....	....	Post's Flora.
208. do.	Do. var. *hispidula*, Boiss.	....	Mount St Katharine.	Do.
209. do.	*Galium sinaicum*, (Decn.) Boiss.	....	Sinai Convent and Raha Plain in fissures of rock.	Kneucker Coll. P.F.
210. do.	*Galium tenerum*, Gaud.	....	Sides of Gebel Katharina 1850-1900 m.	Do. P.F.
211. do.	*Galium Decaisnei*, Boiss.	....	Rocks and shady places. Wadi Aleyat (Serbal).	Do. P.F.
212. do.	*Callipeltis cucullaria*, (L.) Boiss.	....	Raha Plain.	Do.
213. do.	*Callipeltis aperta*, Boiss. et Buhse.	....	....	Post's Flora.
XXVII.—DIPSACEÆ.				
214. *Dipsaceæ.*	*Scabiosa arenaria*, Forsk.	....	....	Do.
215. do.	*Scabiosa eremophila*, Boiss.	....	....	Do.
216. do.	*Pterocephalus sanctus*, Dan.	Samma.	....	Do.
XXVIII.—COMPOSITÆ.				

219.	do.	*Asteriscus pygmæus*, Coss. et Dur.	....	Feiran Oasis and Maghara.	Do.	
220.	do.	*Asteriscus graveolens*, (Forsk.) Boiss.	Nimwar, &c.	Between Feiran and Maghara, and at Maghara.	Do.	P.F.
221.	do.	*Asteriscus Schimperi*, Boiss.	....	Sinai only.	Post's Flora.	
222.	do.	*Pulicaria undulata*, (L.) Boiss.	Rabboul.	Wadis Isla and Tarfa, Feiran Oasis.	Kneucker Coll.	O.S.
223.	do.	*Pulicaria Arabica*, Cass.	....	Feiran Oasis.	Do.	
224.	do.	*Pulicaria longifolia*, Boiss.	....	Moist places.	Post's Flora.	
225.	do.	*Filago spathulata*, var. *prostrata*, Boiss.	....	Sandy places.	Do.	
226.	do.	*Ifloga spicata*, Forsk.	Kureishat-el-Judai.	Near coast and sandy floor of valleys.	Hume Coll.	K.C.
227.	do.	*Phagnolon nitidum*, Fres.	Khananet-en na'gah.	Er Raha Plain and Wadi Aleyat.	Kneucker Coll.	
228.	do.	*Leyssera capillifolia*, Willd.	Oreib.	Common.	Do.	O.S.
229.	do.	*Inula glutinosa*, D.C.	....	....	Ord. Surv. Coll.	
230.	do.	*Iphiona juniperifolia*, Cass.	Oshbeh.	....	Do.	
231.	do.	*Iphiona scabra*.	Dafara.	Characteristic East Sinai Plant.	Hume Coll.	K.C.
232.	do.	*Varthemia montana*, Vahl.	Huneidah.	Rocky soil, base of Sinai.	Post's Flora.	
233.	do.	*Francœuria crispa*, Forsk.	Qutqat and many others.	Dry sandy soil, as dithdath at Mount Sinai.	Schweinfurth Coll.	
234.	do.	*Gymnarrhena micrantha*, Desf.	....	Sandy places.	Post's Flora.	
235.	do.	*Anvillea Garcini*, Burm.	....	....	Do.	
236.	do.	*Achillea fragrantissima*, Forsk.	Qaisun.	....	Do.	
237.	do.	*Lasiopogon muscoides*, (Desf.) Boiss.	....	Sandy valley beds in small plants.	Kneucker Coll.	
238.	do.	*Gnaphalium pulvinatum*, Del.	....	Between Wadi Feiran and Maghara.	Do.	
239.	do.	*Anthemis deserti*, Boiss.	....	Lower Wadi Sheikh.	Do.	
240.	do.	*Anthemis melampodina*, Del.	Erbayan.	Nubian Sandstone plains.	Hume Coll.	
241.	do.	*Anthemis Kahirica*, Visiani.	....	Convent of St Katharina.	Post's Flora.	
242.	do.	*Anthemis rotata*, Boiss.	....	....	Do.	
243.	do.	*Chrysanthemum coronarium*, L.	....	Valley of Rephidim.	Do.	
244.	do.	*Pyrethrum santolinoides*, D.C.	Myrr.	Abundant on Sinai and other peaks.	Hume Coll.	K.C.
245.	do.	*Brocchia cinerea*, (Del.) Boiss.	Afrach., &c.	Abundant, especially in bed of valleys.	Kneucker Coll.	P.F.
246.	do.	*Artemisia herba-alba*, var. *laxiflora*, Boiss.	Shih.	The *densiflora* variety ghoreyra at Mount Sinai.	Do. Schweinf.	Coll.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXVIII.—COMPOSITÆ, (*continued*).				
247. *Compositæ.*	*Artemisia Judaica*, L.	Betheran.	Ubiquitous.	Hume Coll., &c.
248. do.	*Artemisia monosperma*, Del.	'Adah.	....	Post's Flora.
249. do.	*Senecio Decaisnei*, var. *subsimplex*, Bornm.	Mururah, etc.	Rocks and sandy places frequent.	Kneucker Coll. P.F.
250. do.	*Senecio coronopifolius*, Desf.	Jerjir, etc.	....	Barron Coll. K.C.
251. do.	*Senecio flavus*, Schz.	Wein.	Common in south.	Hume Coll.
252. do.	*Calendula palestina*, Boiss.	Kahleh.	....	Barron Coll.
253. do.	*Calendula arvensis*, L.	....	.. .	Ord. Surv. Coll.
254. do.	*Tripteris Vaillanti*, Dec.	....	Sinai only.	Post's Flora.
255. do.	*Echinops glaberrimus*, D.C.	Khashir.	Abundant in mountains.	Hume Coll.
256. do.	*Atractylis flava*, Desf.	Akersh or Khosheruf.	Wadi Werdan.	Kneucker Coll. P.F.
257. do.	Do. var. *glabrescens*, Boiss.	....	W. Aleyat (Serbal) 650-750 m.	Do.
258. do.	*Carduus tenuiflorus*, L.	Khudan.	....	Ord. Surv. Coll.
259. do.	*Onopordon arabicum*, L.	....	....	Do.
260. do.	*Onopordon ambiguum*, Fres.	....	Waste places.	Post's Flora.
261. do.	*Amberboa Lippii*, L.	....	Sandy places.	Do.
262. do.	*Amberboa crupinoides*, Desf.	....	Wadi Berra.	Barron Coll.
263. do.	*Centaurea* sp. near *C. Postii*, Boiss.	....	Wadi Tarfa.	Kneucker Coll.
264. do.	*Centaurea araneosa*, Boiss.	....	Wadi Aleyat (Serbal).	Do.
265. do.	*Centaurea eryngoides*, Lam.	....	....	Ord. Surv. Coll.
266. do.	*Centaurea sinaica* D.C.	....	....	Post's Flora.
267. do.	*Centaurea ægyptiaca* L.	Marur.	....	Ord. Surv. Coll.
268. do.	*Zoegea purpurea*, Fres.	....	Wadi Aleyat.	Kneucker Coll.
269. do.	*Carduncellus eriocephalus*, Boiss.	....	Wadi Werdan.	Do.
270. do.	*Pheopappus scoparia*, Sieb.	....	....	Ord. Surv. Coll.
271. do.	*Koelpinia linearis*, Pall.	....	Debbet er Ramleh, Wadi El Sheikh, etc.	Barron Coll. K.C.
272. do.	*Picris cyanocarpa*, Boiss.	Numwerta-el-Hadan.	Valleys of Sinai.	Hume Coll. K.C.
273. do.	*Picris sulphurea*, Del.	....	....	Post's Flora.
274. do.	*Leontodon hispidum*, L.	Khozan.	....	Ord. Surv. Coll.
275. do.	*Lactuca undulata*, Ledeb.	....	El Bustan, foot of Sinai.	Post's Flora.

276.	do.	*Lactuca scariola*, L.	....	....	Do.	
277.	do.	*Lactuca orientalis*, Boiss.	Yakhiss.	....	Schweinfurth Coll.	
278.	do.	*Urospermum picroides*, (L.) Boiss.	....	Wadi Tarfa.	Kneucker Coll.	
279.	do.	*Scorzonera mollis*, M.B. var. *gabrata*, Bornm.	....	Near summit of Gebel Katharina 2450 m.	Do.	
280.	do.	*Scorzonera Schweinfurthi*.	....	Wadi el-Akhdar.	Barron Coll.	
281.	do.	*Zollikoferia Arabica*, Boiss.	Haudhan, etc.	Between Wadis Werdan and Gharandel.	Kneucker Coll.	P.F.
282.	do.	*Zollikoferia nudicaulis*, (L).	....	Ubiquitous.	Hume Coll.	K.C.
283.	do.	*Zollikoferia glomerata*, (Cass.) Boiss.	Halawat-el-Ghazlan.	Between Wadis Maghara and Shellal.	Kneucker Coll.	P.F.
284.	do.	*Zollikoferia spinosa*, Forsk.	Kebad.	Ubiquitous.	Hume Coll.	K.C.
285.	do.	*Zollikoferia mucronata*, Forsk.	....	....	Post's Flora.	
286.	do.	*Zollikoferia fallax*, Jaub. et Sp.	Marurah or Huwwah.	....	Do.	
287.	do.	*Picridium Orientale*, D.C.	....	Widely distributed.	Kneucker Coll.	
288.	do.	*Picridium tingitanum*, L.	Elbeden, etc.	....	Ord. Surv. Coll.	
289.	do.	*Picridium* do. var. *minor*, Boiss.	....	....	Post's Flora.	
XXIX.—CAMPANULACEÆ.						
290.	*Campanulaceæ*.	*Campanula dulcis*, Den.	....	Rocky slopes.	Do.	
XXX.—SALVADORACEÆ.						
291.	*Salvadoraceæ*.	*Salvadora persica*, Garcin.	Arrak.	Coast of Gulf of Akaba.	Hume Coll.	
XXXI.—ASCLEPIADEÆ.						
292.	*Asclepiadeæ*.	*Solenostemma arjel*, Hayne.	Arjel.	....	Ord. Surv. Coll.	
293.	do.	*Gomphocarpus fruticosus*, R. Br.	do.	....	Do.	
294.	do.	*Gomphocarpus sinaicus*, Boiss.	do.	In many mountain valleys.	Hume Coll.	K.C.
295.	do.	*Calotropis procera*, (Willd), R.Br.	....	Especially in eastern valleys.	Do.	K.C.
296.	do.	*Daemia cordata*, R.Br. = *D. tomentosa*, Vatke.	Lebben-el-Hamarah.	....	Ord. Surv. Coll.	
297.	do.	*Leptadenia pyrotechnica*, Forsk.	Markh.	Southern Sinai.	Hume Coll.	
298.	do.	*Boucerosia sinaica*, Den.	....	....	Post's Flora.	
XXXII.—BORRAGINEÆ.						
299.	*Borragineæ*.	*Heliotropium luteum*, Poir.	Hismah, etc.	Sandy places.	Post's Flora.	
300.	do.	*Heliotropium Arbainense*, Fres.	Rahah or Qurfeh.	Wadi Berra, Wadis Isla and Tarfa.	Barron Coll. Kneucker Coll.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

National Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXXVII.—BORRAGINEÆ. (*continued*).				
301. *Borragineæ*	*Heliotropium undulatum*, Vahl.	Libit.	Sandy places, fairly distributed.	Kneucker Coll. O.S.
302. do.	*Heliotropium persicum*, Lam.	....	Lower Wadi Sheikh.	Do.
303. do.	*Anchusa ægyptiaca*, (L.) D.C.	....	Wadi Tarfa, Wadi el Sheikh, Feiran Oasis.	Do.
304. do.	*Anchusa aggregata*, Lehm.	Temaliq or Qiri.	....	Post's Flora.
305. do.	*Anchusa hispida*, Forsk.	....	....	Do.
306. do.	*Anchusa Milleri*, Willd.	Kahali.	....	Barron and Hume Coll.
307. do.	*Trichodesma Africanum*. (L.) R. Br	Hamimah.	Widely distributed.	Kneucker Coll. O.S.
308. do.	*Trichodesma* do. var. *Ehrenbergii*, Post.	....	Sinai only.	Post's Flora.
309. do.	*Paracaryum micranthum*, Boiss.	Suleisileh.	Widely distributed.	Kneucker Coll. P.F.
310. do.	*Paracaryum rugulosum*, D.C.	Um Libbeid.	Er Raha Plain, at the Convent and Wadi Seba'iaa.	Do. P.F.
311. do.	*Echinospermum spinocarpum*, (Forsk.) Boiss.	....	Similar to above.	Do. P.F.
312. do.	*Echinospermum sinaicum*, D.C.	....	Sandy places.	Post's Flora.
313. do.	*Echiochilon fruticosum*.	Mugheira or Kahhaleh.	....	Do.
314. do.	*Alkanna orientalis*, (L.) Boiss.	Libit.	Wadi Isla, Tarfa, etc.	Kneucker Coll. P.F.
315. do.	*Myosotis hispida*, Schlect.	Lisan-eth-Thaur.	Hillsides.	Post's Flora.
316. do.	*Arnebia decumbens* (Vent.).	....	Wadi el Sheikh.	Kneucker Coll.
317. do.	*Arnebia hispidissima*, Spreng.	Attahn.	....	Post's Flora.
318. do.	*Arnebia linearifolia*, D.C.	Kahali, etc. Awaynet-el-mousleman.	Sands.	Barron Coll. Schweinfurth Coll.
319. do.	*Arnebia tinctoria*, Forsk.	Shojarat-el-Anab.	....	Post's Flora.
320. do.	*Lithospermum callosum*, Sibth. et Sm.	....	Widely distributed.	Kneucker Coll.
321. do.	*Echium sericeum*, Vahl.	Saq-el-Hamam or Lisan-el-Asal.	Sandy places.	Post's Flora.
322. do.	*Echium longifolium*, Del.	....	....	Do.
323. do.	*Echium Rauwolfii*, Boiss.	Keheila, etc.	....	Do.

XXXIII.—GENTIANACEÆ.					
324. *Gentianacæ.*	***Erythræa ramossissima*, Pers.**	....	**Feiran.**	**Kneucker Coll.**	
XXXIV.—CONVOLVULACEÆ.					
325. *Convolvulaceæ.*	***Convolvulus hystrix*, Vahl.**	Shibrim.	Wadis Gnai and Hebran.	Hume Coll.	
326. do.	*Convolvulus lanatus*, Vahl.	Barhaimah or Rehamah.	Desert between Wadi Werdan and Suez.	Barron Coll.	K.C.
327. do.	*Convolvulus Schimperi*, Boiss.	....	Between Feiran Oasis and Maghara, also Gharandel and Werdan.	Kneucker Coll.	
328. do.	*Cuscuta brevistyla*, A. Braun.	....	....	Post's Flora.	
329. do.	*Cuscuta arabica*, Fres.	....	....	Do.	
XXXV.—SOLANACEÆ.					
330. *Solanaceæ.*	*Solanum nigrum*, L.	Anab-ed Dib.	Wadi Tarfa.	Kneucker Coll.	O.S.
331. do.	*Solanum sinaicum*, Vahl.	....	Sinai only.	Post's Flora.	
332. do.	*Solanum retroflexum.*	Anab-ed Dib.	Wadi Emlaha.	Hume Coll. Barron Coll.	
333. do.	*Withania somnifera*, L.	Sharmah and many others.	....	Ord. Surv. Coll.	
334. do.	*Lycium arabicum*, Schweinf.	....	Wadi Sa'al, etc.	Hume Coll.	K.C.
335. do.	*Hyoscyamus muticus*, L.	Sakran.	Ubiquitous.	Do.	K.C.
336. do.	*Hyoscyamus pusillus*, L.	Sufeira.	In hilly parts.	Kneucker Coll.	P.F.
337. do.	*Hyoscyamus albus*, var. *repandus*, Post.	Seikeran.	....	Post's Flora.	
338. do.	*Hyoscyamus boveana*, Dun.	Do.	Near Wadi Aad.	Hume Coll.	
XXXVI.-SCROPHULARIACEÆ.					
339. *Scrophulariaceæ.*	*Verbascum sinaiticum*, Benth.	Reira.	Sides of Mt Sinai.	Do.	K.C.
340. do.	*Verbascum Schimperianum*, Boiss.	....	....	Post's Flora.	
341. do.	*Celsia parviflora*, Dec.	Nefleh.	....	Do.	
342. do.	*Linaria ægyptiaca*, (L) Dun.	D'hami and many others.	Wadi Isla to Gebel Serbal.	Kneucker Coll.	O.S.
343. do.	*Linaria simplex*, D.C.	....	Wadi Tarfa and Er Raha Plain.	Do.	
344. do.	*Linaria macilenta*, Sec.	Halaweh.	....	Ord. Surv. Coll.	
345. do.	*Linaria hvelava*, Forsk.	Nimwar. etc.	Wadi Sigg.	Barron Coll.	
346. do.	*Linaria ascalonica*, Boiss at Ky.	....	....	Post's Flora.	
347. do.	*Linaria spuria*, Willd.	....	....	Ord. Surv. Coll.	
348. do.	*Anarrhinum pubescens*, Fres.	Arphaiji.	Rocks, base of Sinai.	Post's Flora.	

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XXXVI.-SCROPHULARIACEÆ (*continued*).				
349. *Scrophulariaceæ.*	*Antirrhinum orontium*, L.	Saisam.	....	Post's Flora.
350. do.	*Scrophularia xanthoglossa*, Boiss. β. *decipiens*, Boiss.	....	Foot of Ras Safsaf.	Kneucker Coll.
351. do.	*Scrophularia libanotica*, Boiss.	....	Summit of Gebel Katharina 2600 metres.	Do.
352. do.	*Scrophularia deserti*, Del.	Zeiteh.	El Bustan, Sinai.	Post's Flora.
353. do.	*Scrophularia* aff. *Kotschyi*, Boiss.	....	....	Ord. Surv. Coll.
354. do.	*Lindenbergia sinaica*, (Desn.) Benth.	....	Wadis Isla and Tarfa.	Kneucker Coll. P.F.
355. do.	*Veronica anagallis*, L.	....	Moist places in Wadi Tarfa.	Do. O.S.
356. do.	*Veronica macropoda*, Boiss.	....	Near summit of Gebel Katharina, 2000-2500 metres.	Do.
357. do.	*Veronica beccabunga*, L.	....	Wet places.	Ord. Surv. Coll.
XXXVII.—OROBANCHACEÆ.				
358. *Orobanchaceæ.*	*Cistanche tubulosa*, Wight.	....	Parasitic on tamarisk.	Kneucker Coll.
359. do.	*Phelipæa tubulosa*, Schenk.	Therthur.	Do.	Post's Flora.
XXXVIII.—ACANTHACEÆ.				
360. *Acanthaceæ.*	*Blepharis edulis*, (Forsk). Pers.	Shank-ed-Dibb.	Between Feiran Oasis and foot of Serbal.	Kneucker Coll. P.F.
XXXIX.—GLOBULARIEÆ.				
361. *Globulariæ.*	*Globularia arabica*, Jaub.	....	Near top of Serbal ab. 1900 m.	Do. O.S.
XL.—VERBENACEÆ.				
362. *Verbenaceæ.*	*Avicennia officinalis*, L.	Shora.	Growing on shores of Gulf of Akaba.	Hume Coll.
XLI.—LABIATÆ.				
363. *Labiatæ.*	*Lavandula coronopifolia*, Poir.	Zeiteh.	Southern Sinai.	Do.
364. do.	*Lavandula pubescens*, Dec.	....	....	Post's Flora.
365. do.	*Mentha sylvestris*, var. *angustifolia.*	Hublak.	Ain Shiddik.	Barron Coll.
366. do.	*Mentha tomentosa*, d'Urv.	....	....	Ord. Surv. Coll.
367. do.	*Origanum maru*, L. β. *Sinaicum*, Boiss.	Za'tar.	Gebel 'Arrîbe (1700 m.) and between Feiran Oasis and	Kneucker Coll. P.F.

368.	do.	***Origanum nervosum***, Vog.	....	....	Ord. Surv. Coll.	
369.	do.	***Thymus decussatus***, Bth.	Zateran.	....	Do.	
370.	do.	***Micromeria sinaica***, Bth.	Suleisileh.	Between Feiran Oasis and Serbal.	Kneucker Coll.	P.F.
371.	do.	*Micromeria* sp.	....	On Gebel Musa, 1900-2000 m.	Do.	
372.	do.	*Salvia spinosa*, L.	....	Wadis Isla and Tarfa.	Do.	
373.	do.	*Salvia lanigera*, Poir.—*S. controversa*, Ten.	Nu'eimeh.	Sandy places Wadi El Sheikh.	Do.	P.F.
374.	do.	*Salvia ægyptiaca*, L.	Ra'al or Shajarat-el-Ghazal.	Between Feiran Oasis and Serbal.	Do.	P.F.
375.	do.	*Salvia deserti*, Dec.	Ghubeish or Shehibi.	Hilly parts.	Do.	P.F.
376.	do.	*Nepeta septemcrenata*, Ehrenb.	....	Wadi Tarfa.	Do.	P.F.
377.	do.	*Stachys affinis*, Fres.	Girtob.	Widely distributed.	Do.	O.S.
378.	do.	*Ballota undulata*, Bth.	Owseh or rassah.	....	Ord. Surv. Coll.	
379.	do.	*Otostegia Schimperi*, Bth.	Ghassah.	Large bush in South Sinai.	Hume Coll.	
380.	do.	*Otostegia mollucoides*, (Vahl.) Jaub. et Sp.	....	Wadi Isla.	Kneucker Coll.	P.F.
381.	do.	*Phlomis aurea*, Desn.	....	Gebel Arribe.	Do.	P.F.
382.	do.	*Phlomis angustifolia*, β. *flavescens*.	Awarwar.	....	Ord. Surv. Coll.	
383.	do.	*Ajuga tridactylites*, Gingins.	....	Near summits of Gebel Musa and Katharina.	Kneucker Coll.	
384.	do.	*Teucrium polium*, L.	Ja'adeh.	Between Feiran Oasis and Serbal.	Do.	O.S.
385.	do.	*Teucrium leucocladum*, Boiss.	Do.	Rocks: Wadi Hebran.	Post's Flora.	
386.	do.	*Teucrium sinaicum*, Boiss.	Do.	Rocks.	Schweinfurth Coll.	
XLII.—PLANTAGINEÆ.						
387.	*Plantagineæ*.	*Plantago cylindrica*, Forsk.	Um Labbeideh or Barkhemy.	Widely distributed.	Kneucker Coll.	O.S.
388.	do.	*Plantago amplexicaulis*, Cav.	....	Wadi Isla.	Do.	
389.	do.	*Plantago ovata*, Forsk.	....	Feiran Oasis and between it and Serbal.	Do.	
390.	do.	*Plantago ciliata*, Desf.	....	Wadi Shellal.	Do.	P.F.
391.	do.	*Plantago arabica*, Boiss.	Hashir.	Gebel Arribe, about 1750 m.	Do.	O.S.
392.	do.	*Plantago psyllium*, L.	....	Fairly common.	Do.	
393.	do.	*Plantago phæostoma*, Boiss. et Held.	....	Sands.	Post's Flora.	

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—*(continued)*.

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
XLIII.—NYCTAGINEÆ.				
394. *Nyctagineæ.*	*Boerhaavia plumbaginea*, var. *dichotoma* (Vahl).	Duweinat el Far.	Wadis Isla and Tarfa.	Kneucker Coll.
395. do.	*Boerhaavia* do., var. *glabrata.*	Do.	....	Post's Flora.
396. do.	*Boerhaavia* do., var. *viscosa.*	....	....	Do.
397. do.	*Boerhaavia verticillata*, Poir.	....	....	Ord. Surv. Coll.
XLIV.—AMARANTACEÆ.				
398. *Amarantaceæ.*	*Aerua javanica*, Juss.	Ara.	Wide distribution in Eastern Sinai.	Hume Coll. K.C.
XIV.—CHENOPODIACEÆ.				
399. *Chenopodiaceæ.*	*Chenopodium murale*, L.	Fiss-el-Kilab and many others.	Wadi Gharandel.	Kneucker Coll. P.F.
400. do.	*Atriplex dimorphostegium* Kar. et Kir.	....	Feiran Oasis and Wadi Gharandel.	Do.
401. do.	*Atriplex* aff. *roseum*, L.	....	....	Ord. Surv. Coll.
402. do.	*Atriplex leucocladum*, Boiss.	Rudhl, etc.	....	Post's Flora.
403. do.	*Atriplex farinosum*, Forsk.	Huway or Asfay.	Gebel Naqus.	Do.
404. do.	*Kochia muricata*, (L). Schrad.	Layyah.	Widely distributed.	Kneucker Coll. P.F.
405. do.	*Kochia latifolia*, Fres.	....	Wadis Isla, Tarfa and El Sheikh.	Do. P.F.
406. do.	*Kochia* do., var. *inermis*, Boiss.	....	....	Post's Flora.
407. do.	*Halocnemum strobilaceum*, Pall.	Sabteh.	On coast.	Do.
408. do.	*Arthrocnemum glaucum*, Del.	Ushnan.	Salt marshes, Tor.	Do.
409. do.	*Suæda* vermiculata*, Forsk.	Suweid.	In Gulf of Suez near Ras Abu Zenima.	Kneucker Coll. P.F.
410. do.	*Suæda fruticosa*, L.	Malih.	....	Ord. Surv. Coll.
411. do.	*Suæda monoica*, Forsk.	Asal.	At El Noweiba, etc.	Post's Flora.
412. do.	*Shanginia baccata*, Forsk.	Tartir, etc.	....	Do.
413. do.	*Traganum nudatum*, Del.	Feres, etc.	....	Do.
414. do.	*Haloxylon articulatum*, Cav.	Belbel.	....	Do.
415. do.	*Haloxylon Schweinfurthii*, Aschers.	Rimth.	North of and in Wadi Nasb.	Hume Coll.
416. do.	*Salsola kali*, L.	....	Qa'a Plain.	Kneucker Coll.
417. do.	*Salsola tetragona*, Del.	....	Suez Gulf at Ras Abu Zenima.	Do.

420.	do.	*Salsola* cfr. *S. longifolia*, Forsk.	Hamra.	....	Ord. Surv. Coll.	
421.	do.	*Anabasis articulata* (Forsk), Moq.	Ajram.	Widely distributed e.g. Senned plain.	Do.	
422.	do.	*Anabasis setifera*, Moq.	Hamr.	Typical mountain plant.	Hume Coll.	
	XLVI.—POLYGONACEÆ.					
423.	*Polygonaceæ*.	*Calligonum comosum*, Lher.	Arta.	Wadi Kyd, etc.	Do.	
424.	do.	*Rumex vesicarius*, L.	Hamatha.	Frequent.	Do.	
425.	do.	*Atraphaxis spinosa*, L. var. *sinaica* (Jaub. et Sp.) Boiss.	Suweid.	Jebel Arribe, 1750 m.	Kneucker Coll.	O.S.
	XLVII.—EUPHORBIACEÆ.					
426.	*Euphorbiaceæ*.	*Euphorbia cornuta*, Pers.	Libeineh.	Er Raha Plain and Wadi el Sheikh.	Do.	O.S.
427.	do.	*Euphorbia chamæpeplus*, var. *sinaica*, Boiss. et Gaill.	....	Er Raha Plain.	Do.	P.F.
428.	do.	*Euphorbia obovata*, Dcn.	Libeineh.	Betwein Wadi Rahabeh and Wadi Rutig.	Do.	O.S.
429.	do.	*Euphorbia peplis*, L.	....	....	Ord. Surv. Coll.	
430.	do.	*Euphorbia terracina*, L. var. *prostrata*, Boiss.	....	....	Post's Flora.	
431.	do.	*Andrachne telephioides*, L.	Libbaneh.	Er Raha Plain.	Kneucker Coll.	P.F.
432.	do.	*Andrachne aspera*, Spreng.	Kimmash.	....	Post's Flora.	
433.	do.	*Crozophora tinctoria*, L.	Yera.	....	Ord. Surv. Coll.	
434.	do.	*Crozophora obliqua*, Vahl.	Sammah.	....	Post's Flora.	
	XLVIII.—URTICACEÆ.					
435.	*Urticaceæ*.	*Parietaria alsinæfolia*, Del.	Sh'lit, etc.	Wadis Tarfa and El Sheikh, also near foot of Serbal.	Kneucker Coll.	P.F.
436.	do.	*Forskahlea tenacissima*, L.	Lissaq.	Wadis Isla and Tarfa.	Do.	O.S.
437.	do.	*Ficus pseudo-sycamorus*, Dcn.	Zamyuk, etc.	....	Ord. Surv. Coll.	
438.	do.	*Ficus carica*, L. γ. *rupestris*, Hausskn.	....	Upper part Wadi Tarfa and on Serbal, at 1900m.	Kneucker Coll.	
	XLIX.—SALICINEÆ.					
439.	*Salicineæ*.	*Salix octandra*, Sieb.	Safsafeh.	....	Ord. Surv. Coll.	
	L.—PALMÆ.					
440.	*Palmæ*.	*Phœnix dactylifera*, L.	Nakhl.	Many palm-groves.	....	
441.	do,	*Hyphæne thebaica*, Gaertn.	Dom.	Near Tor.	Post's Flora.	

* Three species of *Suæda* not more closely determined recorded by Kneucker.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—*(continued)*.

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
LI.—COLCHICACEÆ.				
442. *Colchicaceæ.*	*Colchicum fasciculare*, L.	Baisur.	....	Post's Flora.
443. do.	*Colchicum Ritchii*, R. Br.	....	....	Do.
444. do.	*Colchicum Steveni*, Kunth.	....	Gebel Katharina.	Do.
445. do.	*Colchicum velutinum*, Born. et Kneucker.	....	Summit of Gebel Katharina above 2450m.	Kneucker Coll.
446. do.	*Colchicum bulbocodoides*, Brot.	....	....	Ord. Surv. Coll.
LII.—HYDROCHARITACEÆ.				
447. *Hydrocharidaceæ.*	*Halophila stipulacea*, Forsk.	....	On Red Sea.	Post's Flora.
LIII.—ASPARAGACEÆ.				
448. *Asparagaceæ.*	*Asparagus horridus*, L.	....	....	Ord. Surv. Coll.
LIV.—LILIACEÆ.				
449. *Liliaceæ.*	*Asphodelus fistulosus*, L.	Barwal.	....	Do.
450. do.	*Asphodelus tenuifolius*, Cav. β. *micranthus*, Boiss.	Borwaq.	Common.	Hume Coll. K.C.
451. do.	*Allium sinaiticum*, Boiss.	Buttait.	....	Post's Flora.
452. do.	*Allium staminium*, Boiss.	....	Summit of Gebel Katharina.	Do.
453. do.	*Dipcadi erythræum*, Webb.	Bureiyit, etc.	....	Do.
454. do.	*Bellevàlia*, sp.	....	....	Barron Coll.
455. do.	*Gagea reticulata*, Pall. β. *tenuifolia*, Boiss.	....	Near Summit of Gebel Katharina.	Kneucker Coll. P.F.
LV.—JUNCACEÆ.				
456. *Juncaceæ.*	*Juncus effusus* L.	Saumar or Bardi.	Wet places.	Post's Flora.
457. do.	*Juncus punctorius*, L.	....	....	Do.
458. do.	*Juncus maritimus*, var. *arabicus*, Asch. et Buch.	Sammar.	....	Buchenau autor.
459. do.	*Juncus bufonius* L. f. *fasciculiflora*.	....	Moist places in Feiran Oasis.	Kneucker Coll.
460. do.	*Juncus* do., var. *subauriculata*, Buchenau.	....	Do.	Do.
LVI.—NAIADACEÆ.				
461. *Naiadaceæ.*	*Ruppia rostellatus*, Koch.	Henzislud.	Near Tor.	Post's Flora.
462. do.	*Cymodocea rotundata*, Ehr. and Hemp.	....	Tor.	Do.
463. do.	*Cymodocea isoetifolia*		Do.	Do.

				Zenima and W. Gharandel.		
468.	do.	*Holoschœnus australis*,(L.)Fritsch	....	Wadi Tarfa and Feiran Oasis.	Do.	
469.	do.	*Scirpus holoschœnus*, L.	Diss.	....	Ord. Surv. Coll.	
	LVIII.—GRAMINEÆ.					
470.	*Gramineæ*.	*Tricholæna Teneriffæ* (L.) Parl.	....	Lower Wadi Isla, Wadi Tarfa and Aleyat.	Kneucker Coll.	
471.	do.	*Panicum turgidum*, Forsk.	Theman.	Common in East Sinai.	Hume Coll., etc.	
472.	do.	*Pennisetum dichotomum*, (Forsk.) Del.	....	Between Feiran Oasis and Maghara.	Kneucker Coll.	
473.	do.	*Pennisetum elatum*, Hochst.	....	Near Naqb.	Post's Flora.	
474.	do.	*Pennisetum ciliare*, L.	....	....	Do.	
475.	do.	*Pennisetum sinaicum*, Den.	Sabot.	....	Ord. Surv. Coll.	
476.	do.	*Pennisetum cenchroides*.	....	Wadi Hebran.	Barron Coll.	
477.	do.	*Imperata cylindrica*, L.	....	....	Post's Flora.	
478.	do.	*Imperata arundinacea*, Cyr.	....	....	Ord. Surv. Coll.	
479.	do.	*Pollinia distachya*, L.	....	....	Post's Flora.	
480.	do.	*Andropogon hirtus*, L.	....	Lower Wadi Isla and Er Raha Plain.	Kneucker Coll.	
481.	do.	*Aristida cærulescens*, Desf.	....	Widely distributed.	Do.	P.F.
482.	do.	*Aristida ciliata*, Desf.	....	Wadi Um Agraf. In rocky and very sunny spots.	Barron Coll.	K.C.
483.	do.	*Aristida plumosa*, L.	Dhereri, etc.	Qa'a Plain.	Kneucker Coll.	
484.	do.	*Aristida coloptila*, (Jaub et Sp.) Boiss.	Nesi.	Widely distributed.	Do.	
485.	do.	*Aristida obtusa*, Del.	Dereri or Sefsuf.	....	Post's Flora.	
486.	do.	*Aristida brachypoda*, Tausch.	Sefsuf.	....	Do.	
487.	do.	*Aristida hirtigluma*, Steud.	....	....	Do.	
488.	do.	*Stupa parviflora*, Desf.	....	Common in Sinai region.	Kneucker Coll.	P.F.
489.	do.	*Stupa tortilis*, Desf.	Sefsuf.	Common on granitic detritus near Sinai and Serbal.	Do.	
489*a*.	do.	*Stupa barbata*, Desf.	....	....	Post's Flora.	
490.	do.	*Tetrapogon villosus*, Desf.	....	On rocks in Wadi Tarfa, and at Sinai Convent.	Do.	P.F.
491.	do.	*Oryzopsis miliacea*, (L.), Coss. and Dur.	Zibl-Abu-Hoseyn.	Wadi Aleyat and Mount Sinai.	Post's Flora, Schweinfurth Coll.	
492.	do.	*Oryzopsis holciformis*, (M. B.) Hackel.	....	Near summit Gebel Katharine, 2450 m.	Kneucker Coll.	
493.	do.	*Agrostis verticillata*, Vill.	....	Feiran Oasisand Wadi Aleyat.	Do.	
494.	do.	*Polypogon monspeliense*,(L.) Desf	Dheib-eth-The'leb	In moist places.	Do.	O.S.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.		Plant.	Arabic Name.	Distribution.	Collection.	
LVIII.—GRAMINEÆ.—(*cont.*)						
495.	*Gramineæ.*	*Avena barbata*, Brot.	Khafur or Sheifun	Foot of Ras Safsaf.	Kneucker Coll.	O.S.
496.	do.	*Danthonia Forskâlei* (Vahl.)Trin.	....	Very common.	Do.	
497.	do.	*Cynodon dactylon*, L.	Néjil.	Feiran Oasis.	Do.	O.S.
498.	do.	*Setaria glauca*, P. de Beauv.	....	....	Ord. Surv. Coll.	
499.	do.	*Pappophorum brachystachyum*, Jaub et Sp.	....	Feiran Oasis.	Kneucker Coll.	
500.	do.	*Boissiera bromoides*, Hochst.	....	Between Wadi Tarfa and Sinai and Er Raha Plain.	Do.	P.F.
501.	do.	*Phragmites communis*, Trin. var. β. *Isaica*, Coss.	....	Bushes in Wadi Isla and Tarfa.	Do.	
502.	do.	*Lamarckia aurea*, (L.) Mœnch.	....	Wadi Aleyat.	Do.	
503.	do.	*Koeleria phleoides*, Vill.	....	Wadi el Sheikh, Er Raha Plain, and Feiran Oasis.	Do.	
504.	do.	*Koeleria sinaica*, Boiss.	....	....	Post's Flora.	
505.	do.	*Schismus calycinus*, (L.) Coss.	Behmeh or Safsuf.	Common in valleys.	Kneucker Coll.	P.F.
506.	do.	*Schismus arabicus*, Nees.	Abu-Machy.	Mount Sinai.	Schweinfurth Coll.	
507.	do.	*Poa sinaica*, Steud.	....	Summit of Gebel Katharina (2600m. and Er Raha Plain)	Kneucker Coll.	P.F.
508.	do.	*Vulpia inops*, Del.	....	....	Post's Flora.	
509.	do.	*Cutandia memphitica*, (Spreng.) Richter.	....	Feiran Oasis.	Kneucker Coll.	P.F.
510.	do.	*Bromus tectorum*, v. *anisantha*, Hackel.	....	Valleys near Sinai.	Do.	O.S.
511.	do.	*Bromus tectorum*, L. × *Japonicus*, Thunb.	....	Wadi Tarfa (ab. 1100m.).	Do.	
512.	do.	*Bromus flabellatus*, Hackel.	....	....	Post's Flora.	
513.	do.	*Bromus madritensis*, L. var. *Delilei*, Boiss.	....	Feiran Oasis.	Kneucker Coll.	P.F.
514.	do.	*Bromus maximus*, Desf.	....	Do.	Do.	
515.	do.	*Bromus rubens*, L.	....	Do. and Wadi Aleyat.	Do.	P.F.
516.	do.	*Bromus fasciculatus*, Presl.	....	Er Raha Plain and Lower Wadi el Sheikh.	Do.	
517.	do.	*Bromus Japonicus*. Thunb. v. *Sinaica*. Hackel.	2 varieties.	Wadis Tarfa and Isleh, Er Raha Plain and Wadi el	Do.	

519.	do.	*Agropyrum squarrosum*, Roth.	....	....	Schimper Coll.
520.	do.	*Lepturus incurvatus*, L.	Shu'air or Timzein.	Sandy places.	Post's Flora.
521.	do.	*Brachypodium distachyum*, (L.) R. et Sch.	....	Wadi Isla, Er Raha Plain, Maghara.	Kneucker Coll.
522.	do.	*Triticum durum*, Desf. var. *megapolitana*, Kœm.	....	Feiran Oasis (planted).	Do.
523.	do.	*Lolium rigidum*, Gaud.	....	Feiran Oasis.	Do.
524.	do.	*Hordeum murinum*, L.	....	Do. Er Raha Plain and Gebel Arribe.	Do.
	LIX.—CONIFERÆ.				
525.	*Coniferæ*.	*Cupressus sempervirens*, L.	....	Gebel Musa.	Do.
	LX.—GNETACEÆ.				
526.	*Gnetaceæ*.	*Ephedra alata*, Desn. var. *Decaisnei*, Stapf.	Adam.	Common.	Do. P.F.
527.	do.	*Ephedra* cfr. *E. fragilis*, L.	Aldi.	....	Ord. Surv. Coll.

CRYPTOGAMÆ.

	PTERIDOPHYTA.				
528.	*Polypodiaceæ*.	*Adiantum capillus veneris*, L.	....	Near streams in Wadi Isla, Tarfa, etc.	Hume Coll. K.C.
529.	do.	*Notochlæna lanuginosa*, Desf.	....	....	Ord. Surv. Coll.
530.	do.	*Cheilanthus fragrans*, W and B.	Girai.	....	Do.
531.	*Equisitaceæ*.	*Equisetum ramosissimum*, Desf. f. *Firanensis*, Luerssen.	. ..	Feiran Oasis.	Kneucker Coll.
532.	do.	*Equisetum elongatum*, Willd.	Namos.	....	Ord. Surv. Coll.
	BRYOPHYTA.				
533.	*Pottiaceæ*.	*Gyroweisia Mosis*, (Lor.) Par.	....	On Serbal on coarse granite 1500-1600 m.	Kneucker Coll.
533*a*	do.	*Gyroweisia Aaronis*, (Lor.) Par.	....	....	Ehrenberg Coll.
534.	do.	*Didymodon tophaceus*, (Brid.) Jur.	....	On G. Katharina 1900-2100 m. and Serbal, 1800 m.	Kneucker Coll.
535.	do.	*Didymodon Ehrenbergii*, (Lor.) Kindb.	....	In brook, Wadi Tarfa.	Do.
536.	do.	*Barbula gracilis*, (Schleich.) Schwar. var. β. *viridis*, Br. eur.	....	Serbal 1500-1900 m.	Do.
537.	do.	*Barbula vinealis*, Brid.	....	On granite, Serbal, 1950 m.	Do.
537*a*	do.	*Aloina aloides*, (Koch.) Kindb.	....	....	Ehrenberg Coll.
538.	do.	*Crossidium Geheebii*, Broth.	....	On coarse granite, Serbal, 1800-1900 m.	Kneucker Coll.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Arabic Name.	Distribution.	Collection.
	Cryptogamæ—(*continued*).			
BRYOPHYTA.—(*cont.*).				
538*a* *Pottiaceæ*.	*Crossidium squamigerum*, Viv. (Jur.).	....	....	Ehrenberg Coll.
539. do.	*Tortula atrovirens*, (Sm.) Lindb.	....	Serbal, 1500-1900 m.	Kneucker Coll.
540. do.	*Tortula Kneuckeri*, Broth. and Geh.	....	Lower part of Gebel Katharina, 1900-2100 m.	Do.
541. do.	*Tortula rigescens*, Broth and Geh.	....	Gebel Katharina 1900 m. and Serbal 1800-1900 m.	Do.
541*a* do.	*Eucladium verticillatum*, L.	....	....	Ehrenberg Coll.
542. do.	*Encalypta intermedia*, Jur.	....	On Serbal, 1950 m.	Kneucker Coll.
543. *Grimmiaceæ*.	*Grimmia alpicola*, Sw.	....	Do.	Do.
544. do.	*Grimmia anodon*, Bryol. eur.	....	Gebel Arribe, 1700-1800 m. Gebel Katharina 2450, Serbal 1800-1900 m.	Do.
545. do.	*Grimmia sinaica*, Hpe.	....	Gebel Arribe, 1700-1800 m., Serbal 1800-1900 m.	Do.
546. *Bryaceæ*.	*Bryum capillare*, (L).	....	Serbal, 1950 m.	Do.
547. do.	*Bryum cæspiticium*, L.	....	G. Katharina, 1600-2100 m.	Do.
548. do.	*Bryum gemmiporum*, De Not.	....	G. Katharina, 1900-2100 m.	Do.
549. do.	*Bryum atropurpureum*, Whlbg.	....	Do. also G. Musa 1500-1700 m., G. Katharina 1900-2100 m.	Do.
550. do.	*Bryum syriacum*, Lor.	....	Small brook in Wadi Tarfa, 600-1050 m.	Do.
551. do.	*Bryum schleicheri*, Schwgr.	....	....	Schimper Coll.
552. *Hypnaceæ*.	*Brachythecium umbilicatum*, Jur. and Milde.	....	Serbal 1950 m.	Kneucker Coll.
553. do.	*Rhynchostegiella tenella*, Dicks.	....	....	Ehrenberg Coll.
554. do.	*Rhynchostegium rusciforme*, Neck	....	....	Do.
555. *Funariaceæ*.	*Entosthodon templetoni*, Neck.	....	....	Schimper Coll.
556. *Lichenes*.	*Gasparinia elegans*,(Lk.)Thornb.	....	Near summit of Serbal, 1950 m.	Kneucker Coll.
557. *Fungi*.	*Cystopus candidus*, (Pers.) Lèv.	....	On *Diplotaxis harra* in Wadi El Sheikh.	Do.
558. *Characeæ*.	*Chara gymnophylla*, f. *subinermis*	....	Brook in Wadi Isla.	Do.

Natural Order.	Plant.	Distribution.	Collection.
559. *Desmidiaceæ.*	*Mesotænium Kramstai*, var. *Kneuckeri*, Lemmer.	Er Raha Plain (1500 m.).	Kneucker Coll.
560. do.	*Closterium Leibleinii*, Ktzg.	Wadis Tarfa and Isla.	Do.
561. do.	*Cosmarium laxe*, Rabh.	Very common.	Do.
562. do.	*Cosmarium*, do. var. *septentrionalis*, Wille.	Gebel Serbal (1,500 m.), Wadi Tarfa and Er Raha Plain.	Do.
563. do.	*Cosmarium Meneghinii*, Breb.	Er Raha Plain (1500 m.).	Do.
564. do.	*Cosmarium Naegelianum*, Breb. var. *crenulata*, Schmidle.	Wadi Tarfa.	Do.
565. do.	*Cosmarium crenatum*, var. *nana*, Wittr.	Er Raha Plain.	Do.
566. do.	*Cosmarium subcrenatum*, Hantsch.	Wadi Isla.	Do.
567. do.	*Cosmarium subpunctulatum*, Nordst. f. *levis*, Schmidle.	On Serbal (1500 m.), abundant.	Do.
568. do.	*Cosmarium margaritiferum* (Turp), Menegh.	Wadi Isla.	Do.
569. do.	*Cosmarium botrytis* (Bory), Menegh.	Wadi Tarfa.	Do.
570. *Zygnemaceæ.*	*Zygnema stellinum* (Vench.), Ag.	Wadi Tarfa (rare).	Do.
571. do.	*Spirogyra catenæformis* (Hass.), Ktzg.	Foot of Gebel Musa.	Do.
572. *Pleurococcaceæ.*	*Rhaphidium polymorphum*, Fres. var. *falcata*, Rabh.	Sides of Gebel Katharina.	Do.
573. do.	*Scenedesmus bijugatus* (Turp), Ktzg. var. *alternans*, Hsg.	Wadi Tarfa.	Do.
574. do.	*Scenedesmus obliquus*, (Turp), Ktzg.	Wadi Isla.	Do.
575. do.	*Oocystis solitaria*, Wittr.	Wadi Tarfa.	Do.
576. *Hydrodictiaceæ.*	*Pediastrum integrum*, Naeg.	Do.	Do.
577. *Ulotrichaceæ.*	*Ulotrix subtilis*, Ktzg., var. *stagnorum*.	On Gebel Katharina.	Do.
578. *Oedogoniaceæ.*	*Oedogonium cardiacum*, var. *carbonica*, Wittr.	Wadi Tarfa.	Do.
579. do.	*Oedogonium rufescens*, var. *Lundelli*, Wittr.	Do.	Do.
580. do.	*Oedogonium Gunnii*, Wittr.	On Serbal.	Do.
581. *Cladophoraceæ.*	*Cladophora fracta* (Walh.), Brand.	Wadi Isla.	Do.
582. *Sphæropleaceæ.*	*Sphæropla Braunii*, Ktzg.	Er Raha Plain.	Do.
583. *Chroococcaceæ.*	*Chroococcus turgidus*, (Ktzg.), Naeg.	Wadi Tarfa.	Do.
584. *Rivulariaceæ.*	*Calothrix parietina*, Thur.	Er Raha Plain.	Do.
585. do.	*Gloeochotrichia Indica*, Schmidle.	Feiran Oasis.	Do.
586. *Diatomaceæ.*	*Epithemia gibba*.	Common.	Fraas and Ord. Surv. Coll.
587. do.	*Epithemia argus*.	Ayun Musa, Wadi Tarfa and Um Shomer.	Fraas and Drake Coll.

LIST OF PLANTS NOTED IN THE SINAI PENINSULA—(*continued*).

Natural Order.	Plant.	Distribution.	Collection.
	Algæ—(*continued*).		
588. *Diatomaceæ.*	*Epithemia rupestris.*	Wadis Gharba, Zawatin, Gharandel and Bab'a.	Ord. Surv. Coll.
589. do.	*Epithemia turgida.*	Wadis Zawatin, Aleyat, and Hebran.	Do.
590. do.	*Epithemia alpestris.*	Wadi Zawatin.	Do.
591. do.	*Epithemia sorex.*	Wadi Hebran.	Do.
	DIATOMACEÆ.		
592. do.	*Surirella ovalis.*	Ayun Musa and Wadi Gharandel.	Drake and Wilson Coll.
593. do.	*Surrirella ovata.*	Ayun Musa = Moses wells, near Suez.	Do.
594. do.	*Surirella pinnata.*	Do.	Drake Coll.
595. do.	*Surirella linearis*, var. *constricta.*	Wadi Bab'a.	Ord. Surv. Coll.
596. do.	*Cyclotella Kützingiana.*	Ayun Musa and Tor.	Wilson Coll., Haig Coll.
597. do.	*Cymbella (? scotica).*	Wadi Sigilliya.	Ord. Surv. Coll.
598. do.	*Amphora minutissima.*	Wadi Zawatin.	Do.
599. do.	*Cocconeis placentula.*	Ayun Musa, Wadi Aleyat, Gebel Musa and Wadi Hebran.	Ord. Surv. Coll. and Wilson Coll.
600. do.	*Cymatopleura solea.*	Ayun Musa.	Wilson Coll.
601. do.	*Campylodiscus bicostatus.*	Tor.	Haig Coll.
602. do.	*Nitzschia sigma.*	Ayun Musa.	Drake Coll.
603. do.	*Nitzschia linearis.*	Wadis Gharba, Zawatin, Er Rimm and Sigilliya.	Ord. Surv. Coll.
604. do.	*Nitzchia amphioxys.*	Wadi Zawatin.	Do.
605. do.	*Nitzschia minutissima.*	Do.	Do.
606. do.	*Nitzschia dubia.*	Do.	Do.
607. do.	*Pleurosigma lacustre.*	Ayun Musa.	Wilson Coll.
608. do.	*Pleurosigma delicatulum.*	Ayun Musa and Tor.	Wilson Coll., Haig Coll.
609. do.	*Pleurosigma attenuatum.*	Ayun Musa.	Drake Coll.
610. do.	*Stauroneis achnanthes.*	Wadi Gharbeh.	Ord. Surv. Coll.
611. do.	*Stauroneis dilatata.*	Wadi Zawatin.	Do.
612. do.	*Navicula elliptica.*	Wadis Gharba, Zawatin and Er Rimm.	Do.
613. do.	*Navicula rhyncocephala.*	Ayun Musa and Wadi Zawatin.	Ord. Surv. Coll. and Wil-

615.	do.	*Navicula ovalis.*	Do.	Drake Coll.
616.	do.	*Navicula ambigua.*	Wadi Zawatin.	Ord. Surv. Coll.
617.	do.	*Navicula lævissima.*	Do.	Do.
618.	do.	*Navicula mesostyla* (?).	Do.	Do.
619.	do.	*Pinnularia viridula.*	Ayun Musa.	Drake Coll.
620.	do.	*Pinnularia viridis.*	Ayun Musa, Wadi Zawatin and Um Shomer.	Fraas Coll. and Ord. Surv. Coll.
621.	do.	*Pinnularia acrospharia.*	Wadi Gharba.	Ord. Surv. Coll.
622.	do.	*Pinnularia oblonga.*	Wadi Zawatin.	Do.
633.	do.	*Pinnularia acuta.*	Do.	Do.
624.	do.	*Pinnularia radiosa*, var. *acuta.*	Wadi Sigilliya.	Do.
625.	do.	*Synedra fasciculata.*	Ayun Musa.	Drake Coll.
626.	do.	*Synedra fragilis?*	Do.	Wilson Coll.
627.	do.	*Synedra familiaris.*	Do.	Do.
628.	do.	*Synedra radiosa.*	Gebel Musa, Wadis Tarfa, Hebran and Sigilliya.	Ord. Surv. Coll.
629.	do.	*Synedra amphirhyncus* (?)	Wadi Er Rimm.	Do.
630.	do.	*Cocconema lanceolatum.*	Wadi Zawatin.	Do.
631.	do.	*Cocconema cymbiforme.*	Wadi Sigilliya.	Do.
632.	do.	*Gomphonema intricatum.*	Ayun Musa and Wadi.	Wilson Coll. and Ord. Surv. Coll.
633.	do.	*Gomphonema tenellum.*	Ayun Musa and Gebel Musa.	Do.
634.	do.	*Gomphonema dichotomum.*	Gebel Musa.	Ord. Surv. Coll.
635.	do.	*Meridion circulare.*	Wadi Zawatin.	Do.
636.	do.	*Achnanthes subsessilis.*	Ayun Musa and Tor.	Wilson Coll. Haig Coll.
637.	do.	*Achnanthes exilis.*	Wadi Zawatin and Gebel Musa.	Ord. Surv. Coll.
638.	do.	*Achnanthes lineare.*	Wadi Sigilliya.	Do.
639.	do.	*Fragillaria capucina.*	Ayun Musa.	Fraas and Wilson Coll.
640.	do.	*Denticula tenuis.*	Do.	Fraas Coll.
641.	do.	*Odontidium mutabile.*	Wadi Zawatin and Gebel Musa.	Ord. Surv. Coll.
642.	do.	*Tabellaria flocculosa.*	Wadi Gharba.	Do.
643.	do.	*Terpsinoe musica.*	Tor.	Haig Coll.
644.	do.	*Diatoma vulgare.*	Wadi Zawatin.	Ord. Surv. Coll.
645.	do.	*Orthosira punctata.*	Do.	Do.
646.	do.	*Orthosira arenaria.*	Ayun Musa.	Fraas and Drake Coll.
647.	do.	*Mastogloia Smithii.*	Common.	Fraas Coll. and Ord. Surv. Coll.
648.	do.	*Mastogloia lanceolata.*	Wadis Gharba and Gharandel.	Ord. Surv. Coll.
649.	do.	*Colletonema neglectum.*	Wadi Zawatin.	Do.
650.	do.	*Colletonema vulgare.*	Do.	Do.

APPENDIX III.

PREVIOUS LITERATURE.

Though treating in the main of a region immediately outside the area here specially studied, Prof. E. Hull's Memoir on the Geology and Geography of Arabia Petrœa (Palestine Exploration Fund, 1886), contains much that bears directly on the questions dealt with in this volume. With regard to the age of the igneous rocks, he considers these as being certainly more ancient than the Carboniferous, and quotes with approval Dawson's remark as to the remarkable resemblance of the rocks of the African Desert to the Laurentian series of North America, a statement which equally applies to the Sinaitic Peninsula. Two rock series are noted as present in Sinai: 1. An older metamorphic and, 2, a younger plutonic or eruptive. The former includes a grey fundamental granite or gneiss, as well as a group of hornblendic, chloritic, and talcose schists, the whole being penetrated by numerous dykes of granite, porphyry, and diorite. With special reference to Mount Serbal, he calls further attention to the central mass of eruptive granite, which has apparently burst through the flanking gneisses, an observation with which the present writer is entirely in agreement. 2. The Plutonic and Volcanic Rocks have penetrated these older members, either in the form of dykes, or in masses forming ridges and mountains, in the main these are porphyries, passing on the one hand into granites, and on the other into felstones. Hull, 1886.

Prof. Hull has also recognized the presence of Volcanic Fragmental Beds older than the Carboniferous Sandstone, consisting of beds of agglomerate, lapilli, and tuff, and of which he considers the red granites and porphyries as the more deeply seated representatives. An interesting account is given on pp. 37-39, a volcanic district, possibly of Lower Paleozoic or Huronian age, being postulated as existing in the Petra district. Naturally the dykes have attracted special notice, and are divided into an older felspathic, and a newer pyroxenic (hornblende and augite both included) group.

There is but little material to aid us in determining the character of the Cretaceous beds in Sinai itself, these being generally classified as Turonian and Senonian, while the Carboniferous beds have been carried far across the peninsula.

In the chapter on the Dynamical Geology not only is the importance of the Jordan-Araba fault fully recognized, but numerous minor fractures are shown to play an important part, some running parallel to the main dislocation, while others branch off from it in various directions (See figs. 17-19).

In Appendix B., Mr. F. W. Rudler has examined the specimens of rock collected by Prof. Hull, describing the syenitic gneiss from the summit of Jebel Musa, and a red syenitic granite from its flanks. In addition dykes of coarse red

and fine-grained pink granites, diabase and porphyrites have been noted, together with a hornblende-augite andesite from Gebel esh Shomrah.

Fraas, 1867. In "Aus dem Orient," Stuttgart, 1867, pp. 1-32, Prof. Oscar Fraas published some interesting generalizations with regard to the Sinai region. He remarks that in crossing from the sea to the mountains there are no intermediate formations between the youngest marine shore-formations and the oldest crystalline hills, and that through all time these have been absolutely wanting. At the base of Serbal he recognizes: 1. A grey very fine-grained gneiss, the constituents of which are of equal size, so that the mica has been somewhat drawn out in layers. 2. A fine red granite, mainly composed of coarsely crystalline red felspar and large colourless quartz, this forming the summit of the mountain. 3. In these are dykes of diorite-porphyry and porphyrite, and Fraas was struck by the variety of these intrusive rocks, the base-rock in Wadi Feiran being a mica-schist, then follows red granite, diorite, and finally as youngest member a porphyrite.

The oases of Sinai are always to be found in the gneiss, the water being held up by the mica-flakes, the other rocks only giving rise to bare and rocky mountain slopes, while the summit of Serbal owes its jagged character to the differential weathering of the red granite and the diorite dykes piercing it.

In the central Sinai group he recognized: 1. Grey gneiss, consisting of white quartz, some white felspar crystal and grey mica, which lies in layers in the white groundmass. This passes over through many stages to grey mica schist: 2. Dark-grey Syenite, also known as Sinait, containing colourless quartz, white felspar, and dark-green hornblende, the rock being very fine-grained and containing some titanite. 3. Dark-grey Granite, in which colourless quartz is less marked, the felspar of a redder colour, and black mica distributed in small particles. 4. Reddish granite with rose-red orthoclase, colourless quartz, and black mica. 5. Schistose Amphibolite. The hornblende is fine-grained and fibrous, penetrated by thin layers of a colourless quartz. This rock is very common in the upper portion of Wadi Hebran, and forms the pass which leads into the lower Wadi Selâf. 6. Epidote-granite forms a beautiful rock in the central portion of Wadi Hebran. Most prominent is a fine red felspar, between which is a coarse grey-white quartz, the whole mass being penetrated by light-green epidote.

Fraas also concludes that there are traces of glaciers in the whole of Sinai, and cannot agree with Russegger that the limestone fragments sometimes found in the valleys are derived from limestone only overlying the porphyries. The great débris-terraces occurring at each bend of the valleys are regarded as moraines. He also calls attention to the reversed erosion forms of the valleys, the upper portions of which are broad uplands, while lower down they form deep ravines, these fractures being ascribed to the great changes in the orographical relationships.

Walther. In "Die Korallenriffe der Sinaihalbinsel," Prof. J. Walther has mainly dealt with the nature of the coral-reefs, and as this memoir deals with West Sinai, only points of first importance need be here mentioned. He very justly points out that Fraas was mistaken as to the absence of intermediate formations between the shore and crystalline formations, and notes the extent to which faulting has

taken place. While not specially devoting his attention to the igneous or metamorphic rocks, he concludes that it is very probable that the crystalline schists and "Lagergranite" (granitoid gneiss) form the whole of the western slopes of the hills towards the Qa'a desert. The boundary of the "Stockgranite" (coarse granite, not showing gneissose structure) and "Lagergranite" correspond to a number of the most important longitudinal valleys in Sinai, and these probably owe their origin to the different relationships of the two rocks. Attention is also called to the fact that while the present strike of the hills is north-west and south-east, this having been formed after the Nummulite period, the majority of the dykes run south-west–north-east. The gneiss consists in the main of white felspar with dark mica flakes, and higher up of dark hornblende-schists.

Of great importance was his discovery of Cretaceous and Eocene beds with steep dip at the foot of the hills near Wadi Hebran, this showing clearly that these later sedimentaries had actually once covered the igneous core. Further south all the region between Qa'a plain and Wadi Hascheb consisted of granitoid gneiss dipping eastward, overlaid by porphyry tuffs and numerous eruptive rocks, amongst these being spherulitic half-vitreous masses, and a great variety of brightly-coloured dykes, from which Walther concludes that this may be an eruptive centre.

He also draws attention to the intense action of insolation on the minerals of granite and allied rocks. By day the red felspar is warmed, expanding more rapidly than the white quartz, and less than the black mica or hornblende.

Figari Bey, "Studii Scientifici sull'Egitto, etc., Lucca, 1864, pp. 625-238," made a rapid traverse from Tor along the western flank of the Sinai range to Ras Mohammed and Sherm, returning through Wadis Nasb and Dahâb to Central Sinai. He further extended his researches to the greater part of the peninsula, but the scientific results are of little value, the age of the rocks having been determined by their lithological character rather than by palœontological evidence. It need only be stated that Figari recognized Jurassic strata as being widely distributed, a view which has received no support from subsequent travellers, the beds so assigned being distinctively Cretaceous. Figari, 1864.

E. Rüppell, "Reisen in Nubian, etc., Frankfurt, 1829, pp. 179-191, and pp. 241-274," gave one of the earliest topographical descriptions of Arabia Petrœa. He recognized that the Sinai triangle was divided into two distinct parts dependent on the formation present, the division line running from Akaba to the mouth of Wadi Feiran. South of this line are mainly ancient rocks, syenites, porphyries, and micaschists. The mountain chains run mainly from north to south. He further recognized the presence of isolated hillocks of steeply-dipping compact limestones with shell-fragments at several places on the sea-border of the ancient massif, notably north-west of Tor, near Sherm, at Ras Abu Soar and not far from Akaba. North-west of this line the principal formations are horizontally bedded compact limestone together with gypsum, forming a desolate waste. The metal-bearing veins in Wadi Nasb are also mentioned as being of wide extent, and are described in some detail (p. 265). Attention is specially called to the remarkable fissures which form a notable feature at Ras Mohammed and Rüppell, 1829.

in the islands to the west (Jubal, etc.), these being referred to the action of earthquakes.

Chauvet and Isambert, 1890. In the "Itineraire de l'Orient" (Collection des Guides-Joanne), Hachette & Co., the latest edition by Chauvet and Isambert in 1890, gives full details as to Western Sinai, based on the writings of Dean Stanley, Lepsius, Robinson, Palmer and Drake, Henniker, etc. On p. 34 the statement is made that "Toute la partie sud de la peninsule est inexplorée."

APPENDIX IV.

DETAILED STRUCTURE OF IGNEOUS REGION IN EAST SINAI.

As the detailed description of the igneous rocks would practically involve the re-writing of the topography, with the addition of a statement as to the rocks composing the ranges, it is proposed to give a sequence of localities appending a note as to the rocks composing them.

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
WADI ISLA (lower part).	Biotite-gneiss, containing darker and more micaceous bands in places. Red felsite and dark dolerite dykes abundant.
WADI ISLA (east of Wadi Wajid).	Hornblende-granite.
GEBELS ETH THEMNIN and THEMAN.	Coarse red granite. Red and black dykes very common.
GEBEL HORMADJAN.	Coarse quartz-felspar granite at summit, biotite-gneiss at base near Wadi Isla.
In WADI ISLA.	No line can be drawn between the gneiss and granite, but at St. VI. the grey speckled gneissose biotite-granite is replaced by a coarse red variety (often mainly felspar).
North of UM ARAG and eastward.	Noted black dyke traversed by red granitic veins. Coarse red granite.
WADI ETH THEBT.	Bounded by coarse quartz-felspar granite.
GEBEL TELLAT GIMAL.	Fine-grained biotite-granite, much traversed by dykes.
Spur of GEBEL HUMR.	Coarse granite with dykes of porphyrite.
Junction of WADIS ETH THEBT and TARFA.	Dyke of coarse syenite in decomposed biotite granite, which here forms main mass of country.
Head of WADI TARFA.	*Red, very quartzose granite underlying* and *intruding into* the *biotite-granite.*
FERSH SHEIKH EL ARAB.	Quartzose granite with chloritized mica.
Head of WADI RAHABEH.	Biotite-Syenite, traversed by microfelsitic and syenite-felsite dykes.
WADI WA'ERA.	Biotite-granite with dykes.
WADI UM GIRAF.	Dykes carry hœmatite and hydrous oxides of iron.
GEBEL ABU MESUD.	Summit dark felsite or andesite with quartz veins on slope. Red granite apparently at base.
WADI NASB after RAHABEH.	Runs close to junction of coarse granite and biotite-gneiss. The first is a light biotite-granite the latter darker and with more hornblende. In lower portion of ravine dykes remarkably well developed.
WADI HEZA'IMA.	Coarse micaceous granite, finely graphic in places.
EKMA range, WADI NASB.	Dark felsite or andesite.
HEZAIMA to BEIDHA.	Coarse pegmatitic granite, with decomposed biotite.
GEBEL BEIDHA.	As above, with fine dolerite dykes.

* When stated without further qualification, "much traversed by dykes" means by both red felsite and dark dolerite dykes.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL NASB.	Coarse quartzose granite.
GEBEL GERAFAT.	Biotite granite.
GEBEL UM BEDA.	Drusy granite.
Hills round WADI UM GHIRAT	Mainly due to dykes of quartz and syenite-felsite, there being two dyke systems crossing one another.
WADI SENNED.	In biotite-granite, strikingly seamed by dykes.
Mouth of WADI UM RACHAL.	Purple and green schists alternating with granite.
Upper part of WADI UM RACHAL.	Hornblende-syenite, biotite-granite, and granulite penetrated by dykes of dark-green diorite.
GEBEL UM KUBBATH.	Quartz-felsite dyke in fine-grained biotite-granite.
WADI SHETHAN.	Hornblende-biotite granite, traversed by quartz-felsite and dolerite.
GEBEL THA'ALBI and ABU'ZAG.	Biotite-granite, traversed by quartz-felsites, etc. Quartz-veins and pockets, as well as hydrous mica, abundant.
ADAKKAR range.	Formed of acid felsites set close together.
GEBEL ASHARA and GEBEL ABU HAMAD.	Coarse pegmatite with little mica veined by dykes of dolerite.
WADI NASB (after UM RACHAL).	Biotite-granite replaced by coarse red granite.
FERANI RANGE.	Schists and felsites or andesites, with granite in places at the base.
GEBEL OWN.	Coarse granite.
Hills near WADI RAHAB.	Coarse diorite or gabbro, traversed by quartz-syenite, or spherulitic felsites.
Between SHELALA and RAHAB	Igneous conglomerate, with fragments of rhyolite.
Mouth of WADI RAHAB.	Biotite-granite, veined by many dykes.
South of KHLALAT pass.	Chlorite schists and hornfels.
GEBEL UM ZAIMER.	Biotite-granite traversed by dykes of syenite-felsites.
GEBEL ETHMOI TELLAT EL GAZAL and THAIYIB TISSIM.	Mica-schists with dolerite and micaceous granite intruding.
GEBEL ZERIG.	Micaceous-schists and knotenschiefer, traversed by dykes of diabase, quartz, and syenite-felsite. Note also re-cemented quartz pebbles. Andalusite Rock.
WADI KYD, above ETHMOI.	Passage from hornfels and chlorite-schist to mica- and finally to hornblende-schists. Finally sharp junction with coarse biotite-gneiss. In schists dykes of diorite and diorite-felsite.
GEBEL GAZALA.	Coarse granite traversed by dykes of dolerite trending N.E.–S.W.
WADI UM GERAT.	Junction of granite and schists. Granite coarse very quartzose biotite-granite. Higher up rock strikingly banded, a granitoid gneiss being interlaminated with mica- and hornblende-schists. This is succeeded by biotite granite with quartz veins, much folded and fractured, and large dykes of felsite also present.
GEBEL GERAFI.	Schists and gneisses, sometimes granitic, sometimes dioritic lithologically, traversed by thick quartz-felsite dykes.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL TAIBEKH and GEBEL SAHASIA.	Biotite-granite or gneiss, traversed by two systems of dark dioritic veins nearly at right angles to one another, and also by veins of a coarse granite.
GEBEL GENAUI.	Decomposing biotite-gneiss, traversed by veins of coarse red granite and diorite.
WADI JENDELI.	Abundance of dykes of diorite, quartz-felsite, and coarse granite. Dykes usually N.E.–S.W., others cut these at acute angles.
GEBEL MAHARRAMA.	Decomposing biotite-granite, traversed by veins of pegmatitic granite with much epidote.
WADI EL TEMA.	Junction of schists and gneiss. Composite rock produced by intimate mixture of biotite-gneiss and mica-schists. Schist with dykes of red felsites trending north-east.
GEBEL SAMRA.	Main ridge a very magnetic dolerite dyke, the schistose beds being squeezed in between the dykes of dolerite and grey granite.
Head of west end of WADI GEBILA.	Biotite-granite and schistose constituents at first, followed by hornfels, etc., with dolerite and mica syenite-felsite dykes.
GEBEL UM ZERIG.	Hornfels traversed by dykes of syenite-felsite.
GEBEL ATSHAN.	Schists obscured by abundance of gabbro and diabase dykes.
GEBEL GEBILA.	Biotite-syenite in close junction with the schists. In schists dykes N.E. trending syenite felsites and andesites.
Low hills east of above.	Coarse hornblende-biotite granite, traversed by dykes of dark green diorite.
RAS UM BERGA.	Coarse red granite traversed by diabase.
North of WADI SOMMA.	Good mica-schists followed by granite, and again a mixture of mica-schists, granulites and dolerites.
RAS EL HA'IB.	Grey compact schist traversed by purple andesite and dolerite.
WADI EL BEDA to WADI YAHAMED.	Compact grey or light hornfels with dykes containing rounded fragments of granite.
WADI YAHAMED.	Coarse pegmatite and biotite-granite, decomposing into rounded masses, with many dykes.
GEBEL ERGAIN.	Decomposing biotite-granite with dykes of diorite-felsite, coarse pegmatite, and fine-grained granite.
GEBEL UM EKHLIS.	Biotite-granite becoming distinct gneiss in places.
WADI UM METIR.	Quartzose-granite.
GEBEL UM SABBAGH.	Coarsely crystalline granite, with fine felsite dykes in lower ranges.
GEBEL UM ADOWI.	Coarse red hornblende-granite traversed by dykes of diorite.
GEBEL BARAKAT.	Coarse granite traversed by aplites and greenstone.
WADI MANDAR.	Dykes of quartz-felsite and decomposed diorite conspicuous.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL BATTACH.	Coarse granite with dykes of quartz-felsite and diorite, or micro-granite and coarse red granite.
GEBEL THAI'AMIN.	Coarse granite traversed by diorite dykes.
GEBEL HAMRA.	Finer-grained granite than above, diorite veins on lower slopes.
GEBEL UM UWERID.	Coarse granite.
GEBEL UM TARTIR.	Biotite-granite.
GEBEL HASHUBI.	Much decomposed dykes of green felsite.
South end of Sinai.	Red granite with little mica, traversed by dykes of brown-red felsite and dolerite.
GEBEL HEDEMIA.	Red and grey quartzose granite with dykes of diorite and syenite.
WADI AWAJA region.	Maze of hills composed of 1, Biotite-Gneiss, or granite with gneissose structure, the components of which are small. 2, A medium Hornblende-Granite, grey in colour, and 3, A red granite differing only from 2 in colour.
RAS EL NIMR.	Coarse red granite with hornblende.
GEBEL DAJILAT.	Coarse, much decomposed granite.
GEBEL UM ATBAG.	Grey and red hornblende-granite with dykes of mica-diorite and dolerite.
GEBEL ER GEITA.	Biotite-granite traversed by dykes of felsite, and a number of magnetic dolerite dykes trending north-east.
GEBEL HAIMAR.	Riebeckite-granite at summit, otherwise hornblende-granite. Few dykes.
GEBEL AAD.	Base of mountain consists of porphyritic biotite-granite, almost a syenite, veined by pink granites and dolerites or diabases.
GEBEL AAD EL GHARBI.	Biotite-granite of three degrees of coarseness, the most coarse being intlimately associated with thick band of quartz-felsite and diorite.
GEBEL MNIDRI.	Red granite with little mica.
GEBEL KHANASIR and GEBEL MABLEDGE.	Coarse red granite with dykes of spheroidal diabase.
WADI UM MOBERA.	Hornblende-granite replaces coarse red variety.
GEBEL UM ZEINIG.	Hornblende-biotite-granite with porphyritic orthoclase.
GEBEL ETHNARBI.	Hornblende-granite at summit passing into coarse granite type of Sabbagh.
WADI UM ZEINIG.	Hornblende-granite with dykes of diabase. No felsites noted.
2nd JEBEL UM ZEINIG.	Coarse lecomposing granite with magnetic diabase.
GEBEL EL KHOR.	Coarse decomposing biotite-granite at base passing into hornblende-biotite granite above.
GEBEL SAHARA.	Red and grey hornblende-granite traversed by diabase.
GEBEL ERGAIN.	Hornblende-granite with dykes of red granite.
Low granite region of LETIH.	Biotite or hornblende-granite with dykes of quartz felsite and spheroidal diabase.
GEBEL AJUAF.	Red granite with little mica. At summit gneiss, finer-grained with much hornblende.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL MADSUS.	Schist showing near summit, much darker and micaceous below. Felsites, dolerites, and diabases traverse them in bewildering confusion. Felsites trend north-east.
GEBEL BOTROU'IYA.	At base chlorite- and hornblende-schists, traversed by dolerite and pink felsite, summit a syenite of Amlagh type. Here distinctly gneissose.
WADI ADAKKAR.	Mainly bordered by coarsely-bedded schists, except at its head, where gneiss comes in.
Hills north of lower WADI ADAKKAR.	Grey hornblende-gneiss traversed by quartz-felsite and dolerite.
GEBEL UM ALEQ or KHALLA.	Felsite or dark andesite with syenite-felsite, etc., dykes.
GEBEL SOWILA.	Syenite with dykes of quartz-felsite, syenite-felsite and dolerite.
GEBEL UM MALAGA.	Coarse red granite with hornblende traversed by dykes of dolerite.
GEBEL NABA.	Muscovite-Granite.
St. XXVII.	Micaceous schists, in some cases containing garnets.
GEBEL ARABY.	Schists observed by gabbro and red felsite dykes.
GEBEL ABU ESHERAT.	At base gneisses and granulites with dykes of dolerite and diabase. Above a hornblende-granite.
Head of WADY ABU ESHERAT.	Red or white gneisses traversed throughout by dark diabase and red microgranite dykes.
WADI MELHADGE.	Gneiss series with dykes of coarse dolerite or gabbro replaced by massive hornblende-biotite granite itself traversed by dolerites, diabase, and non-quartzose red felsite dykes.
GEBEL UM ZAIREH.	At base dark schists, followed by shiny micaceous schists, at summit compact hornfels. Crest broken by dykes of dolerite and syenite-felsite.
GEBEL GNATHEL.	Red granite traversed by diabase dykes.
Head of WADI GNAI.	Diorite with felsites on east, red granite (muscovite-bearing) on west.
Head of WADI GNATHEL.	Finely-banded gneisses penetrated by biotite-granite.
GEBEL HAMAR EL SAJERAT.	Muscovite-granite traversed by dolerite, microgranite, and fine-grained felsite.
Country North of G. GNAI.	Mainly granitic traversed by basic dykes.
GEBEL GNAI.	Highly quartzose granite.
Hills south of DAHAB peninsula.	Here in succession is met. 1, Highly quartzose granite followed by, 2, Hornblende-biotite syenite with sphene and, 3, Grey or red gneisses.
At back of DAHAB peninsula.	Biotite-granite with felsite and dolerite dykes.
GEBEL MOQHTUT, etc.	Granite rich in quartz and porphyritic orthoclase traversed by dykes of diabase or dolerite.
GEBEL UM ET WEJERA.	Below granite capped by felsites or andesites.
GEBEL MA'IN.	Granite succeeded by fine-grained syenite intimately associated with quartz-felsites and diorite-felsites.

IGNEOUS ROCKS—(*continued*).

LOCALITY	NATURE OF ROCKS, REMARKS, etc.
GEBEL LIJ.	Felsite mainly. Biotite-gneiss also present, while masses of coarse granite have burst through.
GEBEL UM HARAQ and FERANI.	Mainly dark felsites or andesites.
GEBEL ZARAGA.	Dark felsites or andesites traversed by quartz-felsites.
GEBEL ABUKSHEIB.	Biotite-gneiss at base, with felsites above.
GEBEL HAMRA.	Mainly syenite-felsites.
GEBEL SADAGIYA.	Junction of the granite and felsite series.
GEBEL JERAIMDA.	Junction of granite and felsite series. At junction hornblende-granite (with quartz) or biotite-gneiss, the hornblende granite also in fragments in pink granite.
West of WADI RA'IB.	Mica and hornblende syenite with red granite intruding.
GEBEL HAMMAM.	Rocks at base gneissose, but higher up granitic.
NASB GORGE (Eastern end).	Two different types : a non-quartzose syenite and very quartzose red granite, both traversed by dolerite.
GEBEL GURNA.	Easily decomposing biotite-granite traversed by dykes of diabase, quartz-felsite, and quartz veins.
Eastern NASB GORGE (W. end).	Hornblende and mica syenite, with red felsite and dolerite dykes.
GEBEL HEDJAN EL GIMAL.	Striped schists obscured by dykes of syenite-felsite and dolerite.
East of North trending WADI NASB.	Syenite, soon replaced by biotite-granite, the latter traversed by dykes of very quartzose granite and dolerite.
GEBEL ER RUBHA.	Coarse quartzose granite with dykes of dolerite or spheroidal diabase and felsite.
West slopes of FERANI.	Striped schists underlaid by granite, also complex intermixture of dolerite and felsite.
GEBEL EL HEYALA and West side of UM RAIYIG.	Mica-hornblende-granite traversed by dykes of felsite and diabase. Nubian sandstone on summit.
GEBEL ER RAIMSHI.	Nubian sandstone, overlying granite traversed by dykes of dolerites and syenite.
GEBEL UM RAIYIG.	Cenomanian limestones and marls overlying Nubian sandstone, between hills of Nubian sandstone overlying granite.
GEBEL ABU USHTAN, etc.	Biotite-syenite forms base rock of all district round Wadi Sa'al (Hammam).
GEBEL EL ARA'ISH.	Mica diorite, traversed by quartz-felsites.

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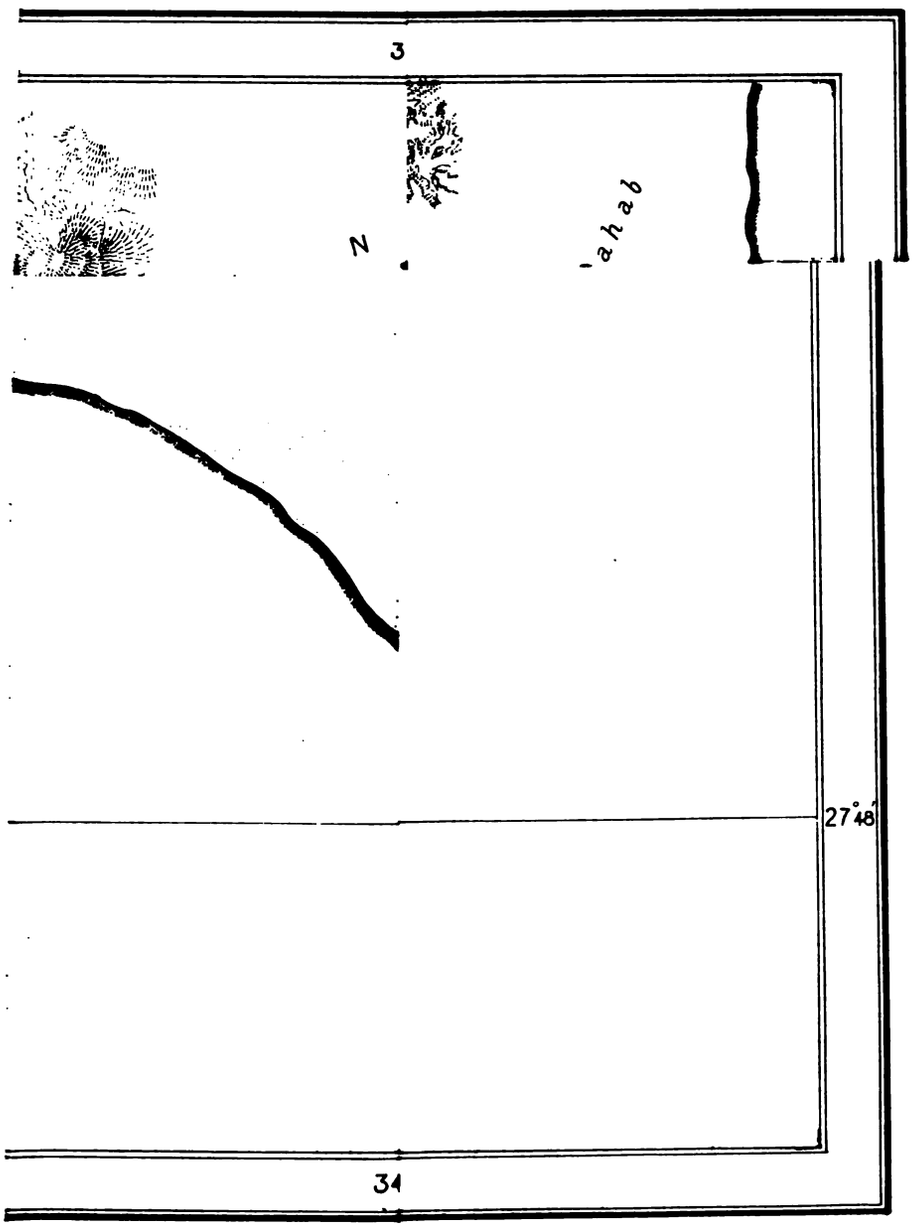

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PLATE XX.

GEOLOGICAL MAP OF SOUTH EAST SINAI.

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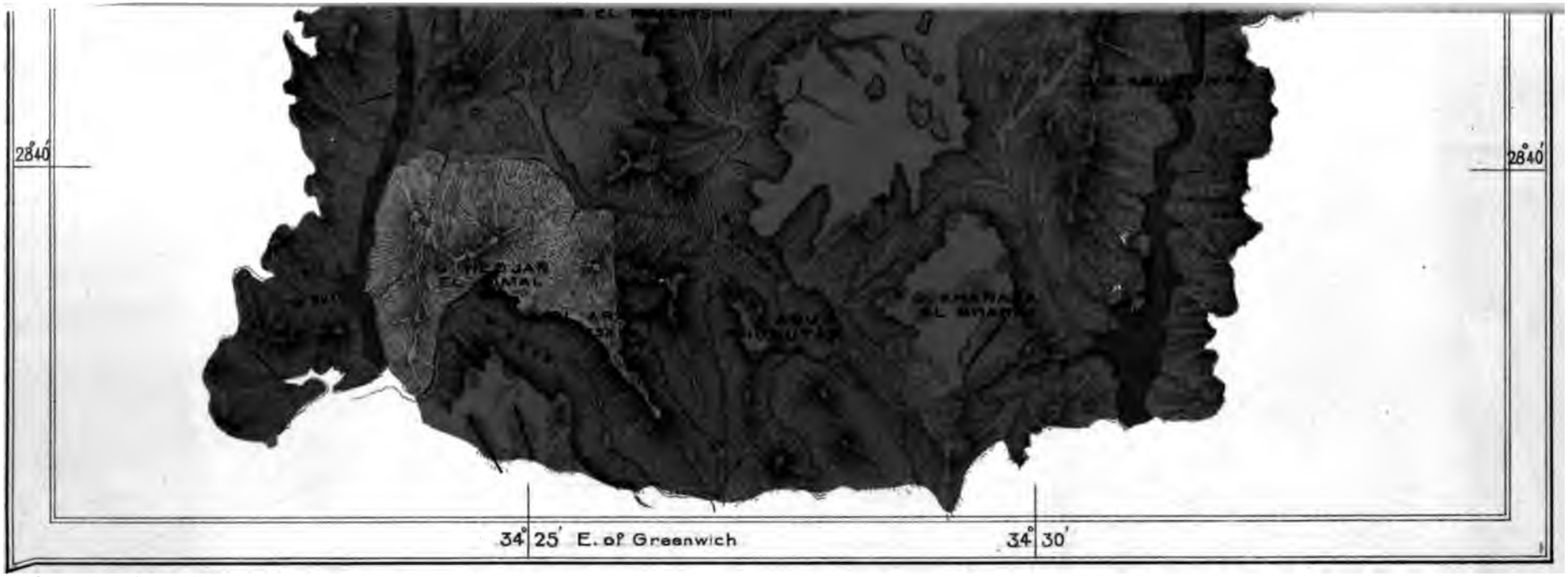
PLATE XXI.

Scale 1 : 62,500

1 2 3 4 5 Kilometres

...a-level as determined by aneroid and hypsometer.



Survey Dept. Cairo 1907.

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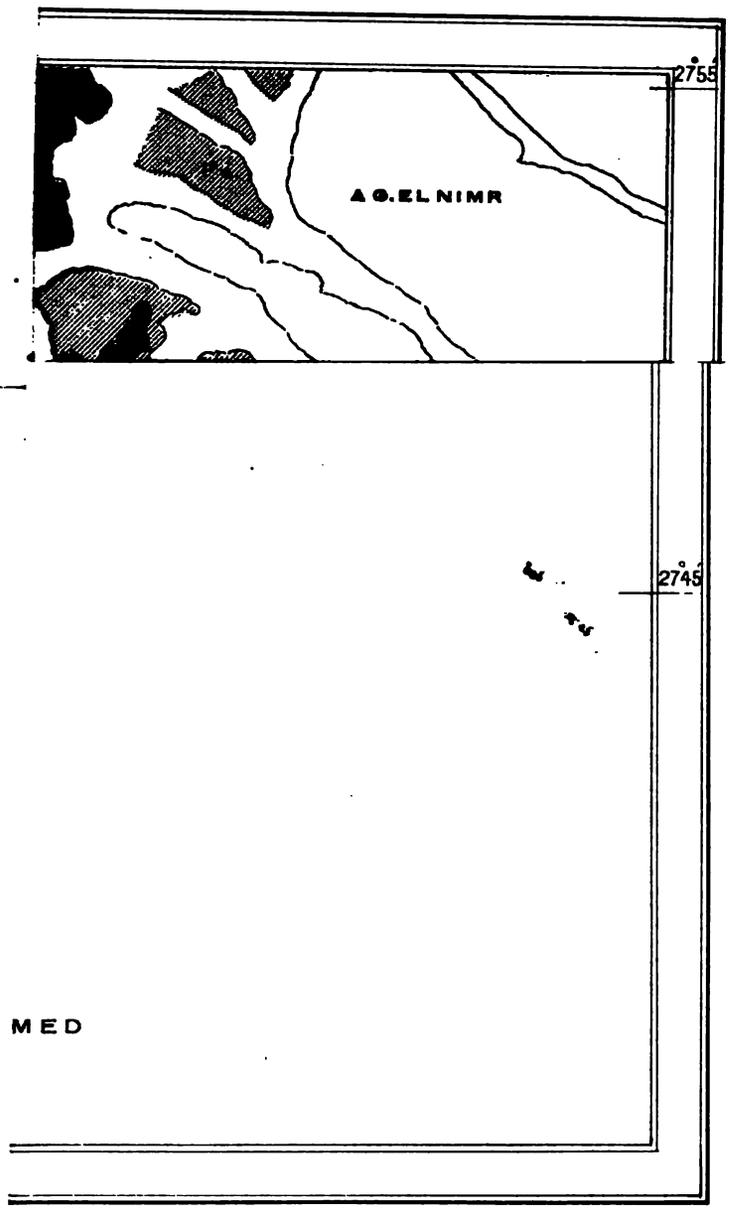
- Pebble Gravels
- Upper Nubian Sandstone
- Lower „ „
- Cenomanian Limestone
- Red Granite
- Schists
- Fault Lines

Scale 1 : 100,000

Metres 1000 0 1 2 3 4 5 Km.

Altitudes given in metres above sea-level as determined by aneroid and hypsometer.

PLATE XXIII.



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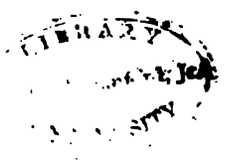

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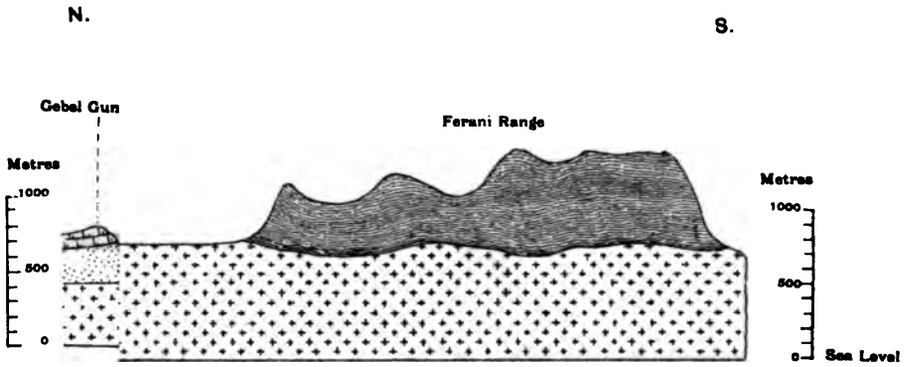
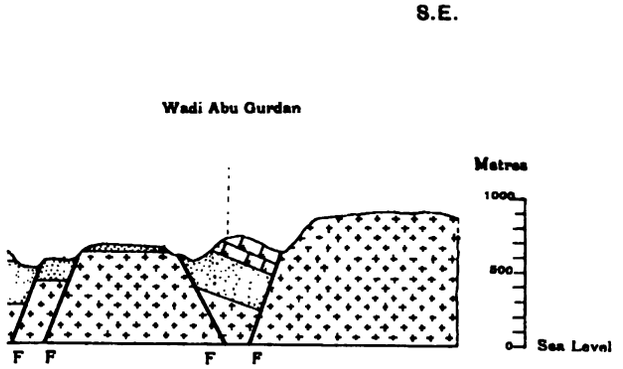
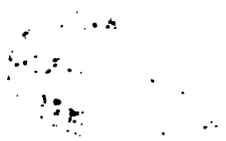




SURVEY DEPT. CAIRO. 1907.



THE

TOPOGRAPHY AND GEOLOGY

OF

WESTERN SINAI

PLATE I.

FERAN OASIS.

SURVEY DEPARTMENT, EGYPT.

THE TOPOGRAPHY AND GEOLOGY OF THE PENINSULA OF SINAI

(WESTERN PORTION)

BY

T. BARRON, A.R.C.S., F.G.S.

CAIRO:
NATIONAL PRINTING DEPARTMENT,
1907.

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PREFACE

The area about to be described was surveyed during the five and a half months extending from the middle of October, 1898, to the end of March, 1899, by myself and by Mr S. T. Hardwick, who took charge of the topographical part of the work. The work was done by traverse up the various wadis crossing the plains, and by ascending commanding hills from which other points could be fixed and the country sketched in. The instruments employed were a measuring wheel, plane-table, and occasionally a tacheometer, while observations were taken every night, if possible, for latitude by altitudes of Polaris. The greater part of the country was done on sheets enlarged from the published maps of the Ordnance Survey of Sinai, on which the outlines of the main wadis were traced and the triangulation points used by the Ordnance Survey officers were transferred. The lower part of the Peninsula was surveyed on blank sheets. In the southern part of the district, work was very difficult on account of the boulder-strewn nature of the wadis, which prevented the use of camels in going up nearer the hills, and of the impossibility of crossing out of one wadi into another, thus entailing a loss of time in descending one valley to reach the next. In the middle of winter, too, the weather was often a hindrance on account of rain and snowstorms, the points often being hidden by clouds. In the spring on the coast-plain sandstorms and winds were of frequent occurrence, the former often causing the stoppage of work for a day, while the wind was often too strong to allow of the plane-table being set up on a hill-top, the compass being so affected that it would not settle. No trouble was experienced from magnetic rocks, as it was always possible to set the plane-table from the triangulation points.

This Report is divided into two parts, the first including a topographical description of the country traversed, a chapter on the Meteorology observed, and another on Natural History Notes. The second part is devoted to the geological structure of the country, including chapters on the tectonics of the district, economic products, and weathering agents.

We are indebted to Herr Guyot of Helwan, for plates I to V and VII illustrating this memoir. Plates VI and VIII were taken by the writer.

T. B.

Cairo, 1905.

Note.—The transfer of Mr. Barron to the Sudan has somewhat delayed the publication of this report. His lamented death at Port Sudan in February last prevented it being finally revised by him so that it is now issued subject only to some minor changes which were deemed advisable.

H. G. Lyons,
Director General.

Cairo, August 1906.

THE

TOPOGRAPHY AND GEOLOGY OF WESTERN SINAI

PART I.

TOPOGRAPHY.

In this report it is proposed to deal with the subject under the following divisions:

1. The plains such as El Qâ, El Markhâ and Debbet el Ramli.
2. The sedimentary area :—
   (*a*) Limestone plateau and parallel ridges.
   (*b*) Low beach plateau to the north of Wadi Gharandel.
   (*c*) Sandstone plateau.
3. The main mountain mass:—
   (*a*) Area north of Wadi Hebrân.
   (*b*) Area south of Wadi Hebrân.
4. An account of the meteorology observed.
5. A short account of the vegetation, etc., as seen during the six months in which the party was at work in the Peninsula.

I.—THE PLAIN OF EL QÂ.

This plain, which extends from Ras Mohammed on the south to within about 6 kilometres south of Wadi Ferân, is bounded on the east by the central hill-range of the peninsula, which is here dominated by Gebel Um Shomer, on the west by Gebel el Araba and Hammam Saidna Musa as far as the village of El Tor, and for the rest of the way by the Gulf of Suez.

The northern part of it is drained by the Wadi el Wadi, which receives all the water which is not lost in the sands and gravel of the plain from Wadis Thaghadi, Thaghêd, El Abura, Geba, Hebrân and Meâr, as well as from the eastern flanks of Gebel el Araba. Although most of the water coming down these wadis disappears in the sands and gravels which form the eastern edge of the plain, a good part of it is eventually thrown out by the limestone which appears

on the western side, and forms a perennial stream in El Wadi; in all probability also it is the source of the hot springs at the foot of Gebel Hammam Saidna Musa. From the level of Wadi Meâr, El Qâ is a level, gravelly expanse of wind-swept plain, there being practically no shelter from the weather, which in summer is uncomfortably hot, while in winter the winds sweep across it with relentless force, making the traveller muffle himself up in his warmest clothes.

Up this plain, parallel with the range of El Araba, goes the camel road from El Tor to Suez, which is the way by which the weekly camel-post conveys the mails to and from these towns. The telegraph line connecting these two places also follows this road pretty closely. Near the head of this plain, another path joins the main Suez road, forming a second and less frequented route from that town by way of Wadi Mokateb and Maghara.

Sikket Abbas Pasha.

Immediately on leaving the bed of El Wadi where it makes its way seawards close to Gebel el Araba, a well-made carriage road is seen running in a north-easterly direction towards Wadi Hebrân, which it enters and follows up to its head. This is called by the Bedawin Sikket Abbas Pasha. Since it was made, the torrents of winter have carried a good part of it away in many places, especially in Wadi Hebrân. From the guides it was learnt that this road was made by Abbas Pasha by means of forced labour; soldiers seized the people and compelled them to work by whips; and in the course of its construction, numerous persons died from the barbarous treatment received. This road was made from El Tor to Gebel Musa where the Pasha at first proposed to build a summer residence, but finding that the hill was so steep, and the work of making a carriage road up it so difficult, it was abandoned in favour of Gebel Qasr Abbas Pasha or Samr el Tinia of the Ordnance Survey, on the top of which the ruins of the palace still stand.

To the south of this road the plain is covered with low mounds of fine clay, sand and igneous pebbles, low hills of limestone and gypsum, and on the east side mounds of boulders of granite and other igneous rocks. To the south of El Tor it becomes a waste of rippled sand mixed with boulders, which, as Ras Mohammed is neared, becomes dotted with outlying patches of igneous hills. On the sea-coast a strip of salt-bearing clay of varying width persists from the southern point to the neighbourhood of Gebêle. Before reaching this village this salty soil was dotted over with mounds of sandy clay, each covered with a growth of tamarisk bushes, or a spiny bush yielding a red berry of a pleasant acid flavour called "Ghargad."

In width this plain varies from 3 or 4 kilometres above the neck of Ras Mohammed to 36 at its broadest part to the south of El Tor, while between Gebel el Araba and the central hill mass, it is 26 kilometres opposite Wadi Hebrân.

At the foot of Gebel Hammam Saidna Musa there is a large grove of date palms, as well as numerous gardens belonging to the monks of the Greek church at El Tor, and from the fruit they brew various kinds of liquors. Between these gardens and the town there is another expanse of sandy ground dotted with mounds bearing "ghargad" bushes.

El Tor

The town of El Tor stands at the head of the bay of that name on a small mound of raised beach, and is surrounded on the landward side by a strip of salty clay which in winter is practically a marsh. It is mainly composed of Arab houses, besides which there is a Greek church and monastery, a post and telegraph office and two consular agencies for Russia and Germany ; other countries used to be represented but have now withdrawn. There is no regular service of steamers from Suez except during the pilgrim season, the town being only occasionally visited by the coast-guard cruiser, or a small sailing-boat which had been engaged to bring down grain and other necessaries for the inhabitants.

Qrum.

A little over two kilometres to the south of the town of El Tor stood the native village of Qrum in its grove of palm trees. Buildings connected with the Quarantine service have now been built on this spot.

Gebêle.

About 4 kilometres further south from Qrum stands the fishing village of Gebêle amongst a few palm trees. It consists only of a few straggling houses of the poorest description, and the people seem to be in great poverty.

Plain of Sêh Sidri and El Markhâ.

This plain, which extends from latitude 28° 48′ N. to near latitude 29° along the coast of the Gulf of Suez, is from 20 to 21 kilometres long, and varies from 2·5 to 7 kilometres in width. It is bounded on its south-east side by the limestone hills of Gebel Nisisât, on the east by the gravel and gypsum plateau and the limestone hill of Gebel Hadûd, the low hills round the mouth of Wadi Baba, and the high gneiss hill-range of Gebel Samra, and on the north by the limestone plateau of Gebel Markhâ. Along the foot of the hills on its eastern

side, mounds of igneous and limestone gravel occur mixed with sand, which, as Gebel Hadûd is approached, give place to blown sand banked up against the lee of this hill, in many cases reaching to its summit, thus offering an easy means of descent from an otherwise impracticable precipice. The surface of this plain slopes gently towards the sea, being covered in the neighbourhood of Wadi Baba with numerous boulders of gneiss, granite and other igneous rocks. Opposite the mouth of the above-mentioned wadi, a sort of delta seems to have formed of the debris brought down by the torrents, which has caused a bifurcation of the bed, one arm going in a westerly direction to the sea, while the other flows north-west and joins the other drainages from the hills on the north-east of the plain, entering the sea near its northern boundary. Across this plain several good camel-tracks are met with, the first, and perhaps the most used, being that which runs almost due south towards Wadi Ferân and thence to El Tor; the second crosses it diagonally to the mouth of Wadi Baba, up which it passes, and thence over Naqb Budra to Maghara, Wadi Mokateb, etc. From both these roads branch-tracks run off to El Markhâ, a pool of water occurring at the foot of Gebel Markhâ. The water is slightly brackish but drinkable, and seemed to be able to water a fairly large number of camels. Close by it is a young palm tree round which seems to be a favourite camping ground of the Bedawin who travel this way. Another well occurs in the gneiss hills to the east about one kilometre up a small wadi. It is not perennial, and yields water only after rain; it is called Bir Dhafâri.

This plain, except for a few stunted seyal trees scattered over its surface, is a very barren place, and offers little food for any animal except after the winter rains. From it a good view is obtained of the hills through which Wadis Baba and Shellâl make their way to the plain. These hills, with the small caps of dark red sandstone on their summits, present a very varied contrast of colour. In the foreground is the yellowish, sand-covered plain; while forming the foothills of the main range are the limestone ridges, behind which come dark-red granite, the dark-grey gneiss, and the red sandstone capping all. Further to the south-east can be seen the fine pink range of which Tatar el Dahami forms the highest point.

Debbet el Ramli.

This plain, which lies between 600 and 700 metres above sea-level, extends from Wadi Siq on the south-east to Wadi Hamr on the

north-west, a distance of 52 kilometres, and has a maximum width of 6 to 7 kilometres. It is bounded on the north-east side by the El Ti escarpment ; on the south-east by Wadi Siq ; on the south and the south-west by the sandstone bordering Wadi Suwiq and the plateau through which Wadi Baba cuts its way, and on the west by Wadi Hamr.

It is drained by the Wadi Siq on the eastern side, and by the Wadis Garf and Bêda on the opposite side, the water finding its way through Wadi Baba to the sea.

Strictly speaking, this is not a plain in the proper sense of the word, but rather an open piece of country resulting from the attrition of the sandstone rocks, small hills of which, capped by basalt or some hard bed, still stand up in the midst of the debris of the adjacent rocks. Against these knolls, huge banks of sand have been piled up, and gradually tail off into the general level of the plain. This, then, is the origin of this plain, viz., the wearing down of the sandstone at the foot of the El Ti scarp, and the removal of it by the wind and piling of it up in another place. Especially is this the case on the south and south-west sides, where the sandstone beds disappear in the general slope of the plateau under these mounds of sand. The slope of the plain, following that of the sandstone beds, is towards the cliff of El Ti, and its lowest point is the wide basin-like bed of Wadi Garf, which runs along the foot of this escarpment for about 16 kilometres, and then bends south-west into Wadi Baba.

On its eastern half it consists at the surface of firm, well-packed gravel and sand, containing numerous pebbles of quartz of various colours, and affords excellent ground for walking upon. But the western half is quite different, consisting either of soft loose sand which is extremely tiring to walk upon, or of bare rock surfaces.

The eastern half of this plain, after the winter rains, affords a fair amount of green food to the numerous flocks of sheep and goats belonging to the Bedawin in this part of the country, in the form of one of the trefoil family (*Trigonella stellata*), which was seen growing abundantly on the firm sand of dunes. The other half, except in the beds of the wadis where various shrubs and plants abound, is absolutely barren.

Across this plain runs the northern road from Suez to the Convent at Gebel Musa, passing up Wadi Shêqer and across the plateau of Elwi el Agramia, through the pass of El Watia in Wadi el Sheikh, and on to its end in Wadi el Dêr.

2.—THE SEDIMENTARY AREAS.

Standing on a commanding point like the northern end of Gebel Serbâl, the contrast between the plains and sedimentary areas, as distinguished from that of the main mountain area, is very clearly seen. While the plains on the one hand have few features to relieve their monotony, the sedimentary area rises in a series of ridges and rounded hills, which present numerous problems of geological interest. In this district, as in practically every other, the topographical features owe their origin to its geological structure. For instance, in the coast ranges of El Araba and Qabeliat, the parallel ridges which compose them are the direct outcome of their geology; the wadi which drains them is due to the erosion of the soft Nubian sandstone; while the low parallel scarps between it and the main cliff of Gebel Araba proper, are produced by the wearing away of the softer marls which alternate with limestone beds, the whole having been tilted by earth movements.

To this latter cause is due the absence of any of the plateau-features which usually characterise sedimentary areas in this part of the globe, the beds having been so dislocated by faults as to have lost their usual horizontal stratification.* On the other hand, the main mountain mass presents bold, rugged peaks towering one above the other in massive grandeur, their sides seamed by steep-walled, narrow gorges down which roll the torrents produced by the heavy thunder-storms so frequent in this district, roaring and leaping over numerous cascades of polished rock, and carrying trees, boulders, and everything before them.

(*a*) Limestone Plateau and Parallel Ridges.

Gebel Hammam Saidna Musa.

Coast ranges of El Araba, Qabeliat, etc.—Commencing from the south at Gebel Hammam Saidna Musa, this hill presents a steep scarp facing El Tor, gradually lowering until it runs to earth in El Wadi. On its seaward side it presents a steep cliff which is almost unscalable, from which it slopes gently, by a series of small steps, eastward to the plain of El Qâ. Along its south-west side remains of Christian chapels and hermits' cells were seen excavated in the rocks. At the foot of the scarp facing El Tor several hot springs issue from the hill, and are led into the gardens owned by the monks for purposes of

Hot Springs.

* These remarks do not include the plateau of El Ti, as that was not explored.

irrigation. There are, however, the remains of ancient baths, some of which are still used by the Arabs during their visits there. These springs are believed by the Bedawin to have remarkable healing powers, and are used by them for various skin diseases, as well as for various rheumatic ailments.

This hill is separated from another—Gebel Abu Suwêra—by the wadi of that name. Its character is similar to the last, and it is capped by a coral limestone which gives it a rough, rugged top. This hill is bounded on the north by the Wadi el Araba, and is connected by a ridge with Gebel Naqus.

Wadi Abu Suwêra takes its origin about the middle of this range, and descends very rapidly through a narrow gorge in the sandstone, often of wonderful wildness, to the sea. A camel path passes over the ridge, at first following the wadi, but later on, owing to the latter descending over small precipices, has to adopt a zigzag course down the hillside.

At the point where this wadi emerges on the sea-coast is a small palm grove, in which a spring of water occurs only a few yards from the sea shore. The water from it was said to have strong aperient qualities.

From the plain of El Qâ the road into Wadi el Araba goes up a small drainage called Wadi el Araba el Sogheira, and crossing the ridges known as Batn el Araba, descends a steep sand slope in a pass near Gebel Naqus.

Musical Sand.

The sand on this slope has been reported by various travellers to give out a booming sound like that of a distant bell, but when crossed by the writer, either owing to unfavourable physical conditions, or to its having been disturbed shortly before, this phenomenon was not observed. That it does occur is undoubted, and in Part I. of the Ordnance Survey of the Peninsula of Sinai, pp. 131 - 134, a detailed account of experiments and observations made on this sand-slope is given.

From the point where this pass enters Wadi el Araba proper, the true parallel character of the ranges becomes established. From the place where this wadi enters the sea a range of igneous rocks commences, at first low and narrow, but gradually becoming higher and wider. The chief rock in this range was a reddish granite, on the landward side of which lay red sandstone.

The total length of the range is between 39 and 40 kilometres. At its southern end it is called Gebel Ghub, but the name for the whole range is Gebel el Araba.

About 26 kilometres further north this range is breached by Wadi el Araba. In order to avoid confusion it is here necessary to explain that the two outlets to this wadi are in all probability due to a dip-fault, which at this point has apparently broken the line of drainage in two, and by the lateral shift, as well as the throwing down of the beds, has diverted the water through the opening in the coast range. This seems the only explanation, as the course of the southern part of the wadi, being parallel with the strike of the beds, was the easiest possible, and unless some powerful agent opened a way through the igneous ridge, the water would never attempt it while it had this much easier course open to it.

Between these two openings, but nearer the northern one, is Gebel Abu Hoswa, one of the highest points of the range, being 692 metres above the sea. Its eastern flank, as well as a large part of the range, is covered by blown sand, which in some cases has reached the top of the ridge.

At its southern end it drops right into the sea, there being not even the width of a path along the shore. As it is followed north, however, a small strip of beach is gradually interposed between it and the sea, and between the northern branch of the wadi and the end of the range there is a good road on the sea-coast.

Its highest and best-marked peak is called Gebel Abu Darba, which is used as a landmark by navigators on this coast. It stands up from the rest of the hill-mass as a sharp, jagged peak, and is seen from the landward side for a good distance as well.

At the northern end of the range where it gives on the wide plain at the mouth of Wadi Ferân, the granite hill is almost buried in blown sand. The seaward side of this ridge is very steep and abrupt, while towards the land it presents a gradual slope.

Batn el Araba. The part of the coast-range known by this name is the series of low parallel ridges which lie between the igneous hills and the limestone ridge bordering the plain of El Qâ. They gradually decrease in height as they approach the latter.

Limestone Range. This extends from the point where the road through the pass at Gebel Naqus enters the range up to the point where Wadi Qabeliat breaches it, a distance of about 40 kilometres. On its western side it presents a sheer, unscalable escarpment, while to the eastward it slopes at a gentle angle until it loses itself in the plain of El Qâ. Its continuation is known by the name of Qabeliat.

The whole of this range, except the eastern slope of the limestone ridge of El Araba, is drained by the Wadi el Araba, which passes out

at three points into the sea. The first opening is at the southern end of the igneous range; the second at the middle where it is broken by the lateral shift of the rocks; while the third is at the northern extremity of the coast-range. The middle branch of this wadi is the most important, as it receives drainage from north and south, as well as the water collected by Wadi Qabeliat which drains the country to the north-east.

Gebel Qabeliat (Mountain fronting the sea).

This hill forms the head of the ranges which have been classed under the term Gebel el Araba. It forms a round, flat-topped mass presenting a steep scarp to the sea, with a low subsidiary plateau at its foot, and sloping gently down on its eastern side towards the plain of El Qâ. It is mainly composed of limestone, but patches of gypsum occur on its eastern flank, and the foot-hills on its seaward side are largely of sandstone. In the small wadis which cut this low plateau, large dunes of blown sand occur, making climbing very difficult, although once the slope is mastered, they make what would be otherwise dangerous or impossible descents easy.

Stretching away from the foot of the low plateau towards the sea is a plain much cut up by water channels and covered by boulders of igneous and other rocks brought down by the Wadi Ferân.

Sedimentary area east of El Qâ, etc.

Gebel Safariat.

Starting from the south, the first patch met with is that of Gebel Safariat, a mass of highly tilted and dislocated strata opposite the mouth of Wadi Hebrân. Topographically it is not of much importance, although of great interest geologically.

Gebel Asfar.

Passing northwards across the plain towards the main plateau, the first part reached is Gebel Asfar, so called from its yellowish colour. It stands in the angle formed by the sedimentary plateau where it abuts on the granite foot-hills of Gebel Serbâl. This hill presents a sheer cliff of 200 metres or so on its south and east sides where it overlooks the junction of Wadi Geba (the valley of pools) with that of Wadi Raqqa, the latter separating the igneous from the sedimentary rocks.

Wadi Raqqa.

At its mouth it is a series of smooth water-worn precipices at the foot of which are fairly large pools of water. From its mouth it is unscalable, but it can be descended with care. This narrow gorge presents some very rugged scenery while it lasts; but a little distance from the mouth the wadi suddenly opens out into a wide, sandy bed with open country between it and Serbâl. Above the gorge, according to the information supplied by the Bedawin, the name of the wadi becomes

changed to that of Geba. Into it flows Wadi Um Lahm which heads in Gebel Um Lahm.

Wadi Geba is a fine broad valley abounding in plants of various kinds, on which numerous camels and goats browse, it being reached by a path across the low hills from Wadi Abûra. Several well-grown seyal trees were also seen in this wadi.*

Wadi Abûra. Passing in a north-westerly direction up the plain, the next wadi met with is that of Abûra (the place of crossing), so-called because the Bedawin say there is a path from this wadi across Serbâl to Ferân. This wadi rises in Gebel Tigellîa, and passing through the ridge of limestone which forms the eastern boundary of the plateau, winds through the low hills in a broad open course, until it enters the plain of El Qâ.

Not far from its mouth is a well of good water with a few palm-trees round it, and some ruined houses near by. Numerous seyal trees also occur in this valley.

Wadi Abu Gurdi. Quite close to this wadi is that of Abu Gurdi. It is only a short valley heading a little distance up in the plateau. Its right bank is formed by a steep escarpment of red sandstone and marl, the left bank being mainly limestone and marl.

Wadi Thaghêd. This is only a short valley which heads in the small plateau to the west of the previous wadi. Here occur a few palms, and water which is slightly salt.

Wadi Thaghadi. About a kilometre north of the last wadi occurs that of Thaghadi —so called on account of the bad dates produced by the palms here which when eaten give a feeling of throttling (Thaghad). It enters El Qâ about 18 kilometres below Wadi Ferân. At its mouth, which is narrow, is a grove of palm-trees with several wells of slightly brackish but drinkable water. These are much frequented by the Bedawin on their way to and from Suez, and form one of the main places where their qirab (water-skins) are refilled. The wadi is entirely blocked by these trees, which extend for about 750 metres. Higher up it widens out, and later on divides into two which go north and east respectively, the former, being the longer, ends in the limestone hills, while the latter heads in the ridge close by. The sides of the wadi are made up of red sandstone for part of its course, this rock being broken up into curious and fantastic knolls, peaks, and ridges which are very picturesque.

* There seems to have been a confusion of names in the wadis mentioned; the lower part of the wadi ought undoubtedly to be called Geba, and the upper part Raqqa (the valley with cultivated sides).

A foot-path is said to go up the eastern branch of this wadi and across the plateau to the west side of Serbâl.

From this wadi until Wadi Ferân is reached there were no valley of importance. The following are their names: Wadi Abiad which comes from behind Gebel el Abiad, a steeply tilted hill of limestone; Wadi Abu Qallam, and Wadi Abu Themâm, which come out of the low plateau of Cretaceous marls; and finally, Wadi Khadahid runs down from Gebel Khadâhid into Wadi Ferân.

The Plateau.

The plateau here is made up of alternate ridge and valley, or anticline and syncline. These ridges extend up to Wadi Thaghadi, and are cut off by what seems to be a small roll of the beds, the upper limestone being removed and leaving a low plateau of marls sloping towards El Qâ. These are bounded on this side by Gebel Abiad and Khadâhid, which are more or less rectangular masses of limestone standing up out of the plain and dominating all the surrounding ridges.

Gebel Ekmi.

Out in the plain, forming the head of El Qâ, are a few low hills of conglomerate and limestone, the chief of which is Gebel Ekmi, and these slope gently to Wadi Ferân.

South side of Wadi Ferân.

The southern side of Wadi Ferân is formed by a mass of limestone sloping towards El Qâ, and ending on its east side in a vertical escarpment along the foot of which runs the Wadi Asl heading in Gebel Asfa. This plateau in outline is rectangular in shape, and ends in a spur where it connects with Gebel el Rigma. The main hill-mass is called Gebel el Asl, while the spur bears the name of El Asfa. This mass of limestone forms the northern boundary of the low-lying tract of marls previously mentioned, a wadi which heads in Gebel el Asfa and joins Wadi Khadâhid separating the two.

Between this limestone plateau and the next ridge there is a lower strip of marls, which ends up in a point at Gebel el Rigma on the south, but runs round the base of the ridge on the side of Wadi Ferân. This ridge is steeply inclined to the west, and presents a steep escarpment to the east, being connected by a series of isolated knolls with the main plateau to the north-east which lies against the igneous hills. On the side of Wadi Ferân it is continued by foot-hills of marl down the boundary of the gneisses opposite Wadi Nisrîn.

North side of Wadi Ferân.

Turning to the north side of Ferân the scenery is very similar to that on its southern side. There are the same foot-hills of marl, above which rises the steep scarp of the limestone, forming a rectangular mass called Gebel Mokateb which slopes west and north-west, and eventually running off in a northerly direction. The ridge of marls ends in Gebel Abu Alaqa, and establishes a watershed between Wadi Sidri and Wadi Ferân.

Gebel Mokateb

Plateau between Gebel Mokateb and Gebel Withr.—This plateau is bounded on the north by Wadi Sêh Sidri and on the south by Wadi Ferân. It consists of a mass of pinkish white limestones, having Gebel Abu Alaqa on its north-east corner, and draining by small wadis into the previously-mentioned main drainage lines. The main drainages falling into Wadi Ferân are the Wadi Khrêsa, which collects the water from Gebel Mokateb, Abu Alaqa, and the northern part of the low plateau; and Wadi Withr, which receives the water from Gebel Withr and the southern edge of this limestone mass. On the Sêh Sidri side there are several short valleys, among which are Wadis Khrêza, Morr and Withr.

Gebel Abu Alaqa. This is a hill rising with precipitous sides from Wadi Sêh Sidri. At its base on this side it consists of granite; but on its eastern side it starts with foot-hills of red sandstone, presenting vertical scarps difficult of access; above these are the steep-sided marls; while, capping all, and accessible only at certain places, are beds of flint conglomerate. Having reached the summit, an excellent view of the surrounding country is obtained. This hill is one of the trigonometrical stations of the Ordnance Survey, and stands a little over 240 metres above sea-level. Towards the west it drops down steeply to the low limestone plateau.

Passing across this plateau it was found that a good deal of blown sand has been laid down in the depressions, apparently largely derived from the limestone itself. Going westward a lower plateau of gypsum is crossed, called Gebel Morr, and about 3 or 4 kilometres further west Wadi Withr is reached, the scarp of this gypseous mass forming its eastern side. This plateau of gypsum and limestone is continued on the north side of Sêh Sidri for some little distance, the former coming to an end on the edge of El Markhâ. The total extent of this limestone plateau is 19.5 by 9.5 kilometres, while that of the gypsum is 13.5 by 3 kilometres.

Wadi Withr. This wadi drains both to the north and south. From the Sêh Sidri side it is difficult going on account of the amount of sand in its bed, and towards its watershed it has to be abandoned for the plateau on account of the small precipices in its course. The part draining southwards is much more open, beginning in a small plain which gradually narrows to a few metres wide as it descends towards Ferân, again opening out after it has made its way through the gypsum into the gravel area on the side of the above-mentioned wadi. This wadi receives all the drainage from Gebel Withr, and along it is the camel track followed by the post-runner between Suez and El Tor.

This is a longitudinal ridge running from the mouth of Sêh Sidri to that of Ferân for a distance of 19 kilometres and having an average width of 2.5 kilometres. At its northern end it presents a sheer scarp on its western side facing the Gulf of Suez, but towards Wadi Ferân a series of low foot-hills run out from it ending in Gebel Khadid el Dhib (the trench of the wolf). Towards Wadi Withr it falls with a slope of about 10°. At its northern end it is divided into two by Wadi Nisisât, the western limb being named Gebel Nisisât. Gebel Withr.

The telegraph line from El Tor via El Qâ to Suez follows the narrow strip of beach from Wadi Ferân to El Markhâ plain, and than across the latter to the mouth of Wadi Tayiba, where it leaves the coast.

From the mouth of Sêh Sidri to that of Wadi Baba there is little of any topographical interest. The low marly and gypseous plateau runs up until it reaches Gebel Hadûd, a limestone hill (probably so called because there are a few veins of tachylyte in it) which presents a bold escarpment to the west, against which blown sand is banked up almost to its summit. The continuation of this hill forms the eastern boundary of El Markhâ at this point ; while to the east, lying in a hollow in the limestone, are some clays, marls and conglomerates with a sharp ridge of limestone dividing them from Wadi Shellâl. Gebel Hadûd.

The plateau of El Markhâ.—This plateau forms a part of the great mass of limestone which extends up to and beyond Wadi Tayiba, and varies from 9 to 16 kilometres in width. It consists of a mass of limestone which has been let down by a fault against the crystalline rocks of the centre of the peninsula. Opposite El Markhâ, near the "Ein" (well) of that name, there is a depression caused by a secondary fracture. Passing round the sea coast, which here is almost covered at high tide, a bold escarpment of flinty limestone is present at Gebel Nokhel near the mouth of the wadi of that name. This wadi drains practically the whole of this side of the plateau. Going northward the road leads over a series of rocky ledges across the headland of Ras Abu Zenîma, so-called from a saint of that name who was buried there. From this point the road runs along a low, gravelly beach, called El Markhîa, to the mouth of Wadi Tayiba. Gebel Nokhel.

From the place where the limestone approaches the shore, a dyke is seen crossing the plateau in an east of south direction, and running out to sea. This is seen after crossing the terraced limestones near Abu Zenîma, where the limestone gives place to the marls, and the country becomes lower.

As the mouth of Wadi Tayiba is approached a conspicuous black ridge standing steeply tilted towards the sea attracts attention on account of its unusual appearance. This is an interbedded lava in the newer deposits of the sea-coast.

Wadi Tayiba.—The entrance to this wadi is very grand, the contrast between the dark bed of lava with the reddish conglomerate and white limestone being very striking. This sheet of lava forms as it were the gate posts of the entrance to the valley. At this point the wadi is only 45 metres wide, and is bounded on either side by vertical cliffs of Cretaceous limestone. About a kilometre from the mouth a few palm trees are seen, a sure sign of water. The road is excellent, being smooth and firm under foot, and where gravel is absent the bed of the wadi is made of a smooth floor of limestone. As the valley is ascended it gradually widens as the cliffs on either side become lower, until it is about 180 metres in width. A little over 2 kilometres from the mouth, and while the wadi is still narrow, a small grove of stunted palm trees and tarfa bushes is met with, near which are several pools of brackish water, unfit for drinking purposes, except in extremity, but useful for washing. On the right and towering above the wadi is a reddish hill with a prominent black band in it, which on being climbed proved to be part of the same conglomerate with interbedded lava that was found at the mouth of the valley. This was seen to extend about 2.5 kilometres eastward, and was connected with the dyke mentioned as present in Gebel Nokhel.

From this hill it was seen that the marls were disappearing to the north-east under a ridge of limestone, which gradually fell away to valley level in the neighbourhood of a prominent hill called Sarbût el Gemel.

From the springs, palms and tarfa bushes the road runs up the wadi for 3 or 4 kilometres between gradually lowering hills until it comes to the mouth of Wadi Shebêka where Wadi Tayiba proper ends. At this point it splits up into three branches ; the most northerly is Wadi Shebêka (so called because of the labyrinth of wadis of which it is made up) ; the middle member, Wadi Mâdat el Melh, which loses itself in the low limestone hills to the north-west, is only practicable for lightly laden camels ; and the last and most easterly, Wadi Hamr (so called from its red colour), which is the main drainage line, is also the road followed by travellers going to Gebel Musa by the northern or central routes.

Wadi Shebêka. This wadi is only about 3.5 kilometres long, and drains the country between Wadi Ethâl and Tayiba. The Suez road turns up this wadi,

the telegraph line likewise following the same course, and after crossing some low country descends into Wadi Ethâl.

Leaving the mouth of Shebêka and passing up Wadi Hamr (here a fine open valley with retem, shia, sakran and other plants), the road runs east between low limestone cliffs 10 to 15 metres high. The floor of the valley is smooth, and makes excellent going. About 3 kilometres from its mouth, it is crossed by the dyke previously mentioned, which at its point of contact with the limestone has blackened it by the development of hydrocarbons. On the sides of the wadi, masses of boulders and gravel occur, on which patches of the plant called Hamad or Hamatha (*Rumex vesicarius*) by the Bedawin grow in great luxuriance. This is a succulent plant with reddish hollow stem and heart-shaped leaves, much sought after by the camels, which eat it readily. It is also eaten by the Bedawin. Wadi Hamr.

About 5 kilometres from its mouth, Wadi Hamr receives its main tributary, Wadi Ibn Sakkar, from the left. This valley, which gets its name from an old legend concerning some man who became insane and lived here on the plant Sakran, is 12 to 13 kilometres long, heads in the sandstone plateau at the foot of El Tî, and receives part of the drainage of Sarbût el Gemel. Opposite its mouth Wadi Nokhl enters from the right, a small and unimportant feeder. Wadi Ibn Sakkar.

At this point the sides of the wadi begin to disappear, and its bed widens out to over a kilometre in breadth, this continuing up to Sarbût el Gemel. Speaking correctly, there is no proper boundary, as the country is practically a plain at this point, with a few knolls of limestone or detritus scattered over it.

This is a bold ridge of limestone and flint conglomerate rising 366 metres above the valley, and resting against the sandstone, which forms the country between it and the plateau of El Ti. It has been let down by the main line of fault, which has thrown down the whole of the plateau to the south against the older crystalline rocks. Sarbût el Gemel.

After passing this ridge the valley enters the sandstone country, and contracts to about 100 metres in width, being bounded by low cliffs on either side. In this area the sandstone presents the scoriaceous appearance so well known in other districts, but the most remarkable phenomenon is the well-rounded appearance of the hills, due to wind and sand action. So well-rounded are they, that at a distance they might be mistaken for granite knolls, so closely in shape and colour do they resemble the latter. About one kilometre below Wadi Qarûra, Sinaitic inscriptions were seen on the rocks.

Seven kilometres from Sarbût el Gemel the mouth of Wadi Qarûra is reached, and here the road bifurcates, the central path to Gebel Musa Wadi Qarûra.

following this valley, while the northern route goes up Wadi Hamr to where it heads in Debbet el Ramli, and thence across this plain. The course of these paths will be described in detail later on.

At this point Wadi Hamr was left, and a rugged path followed over several passes and very bad ground indeed, a road, that until one knows the capabilities of the camels of Sinai, would have been the last to be attempted. This road is as a matter of fact only used for riding camels, but thanks to the good and careful management of the drivers, all the camels, heavily laden with baggage though they were, reached Ras Ethâl in safety.

Ras Ethâl. Near the head of Wadi Ethâl the line of division between El Tî and the low plateau to the west becomes obliterated, the two being connected by a line of flat-topped hills bearing the names of Gebel Madsûs and Abu Dêmat. These consist of Cretaceous marls with sandstone at their base, against which the limestone has been let down by the same line of fault as that met with at Sarbût el Gemel.

For about 4 kilometres from its head this valley is impracticable for camels, on account of the boulders and small precipices in its bed, so the way runs up over the flank of Abu Dêmat, over beds of crystalline limestone rendered slippery and dangerous by sand-action.

At the point where the camel path struck the wadi there were a few well-grown palm-trees, and one or two fine seyals, as well as good water.

On either side of the valley the ground slopes down from Gebel el Tî towards the west. Gebel Abu Dêmat ends in an escarpment facing west, while the continuation of Madsûs runs to valley-level opposite Wadi Hiâla, a tributary of Wadi Qâda. Above this depression rises

Gebel Krêr. the steep escarpment of Gebel Krêr, a narrow limestone ridge cut off by a fault from the main mass; it is a reduplication of the main hill-range of that name.

Further to the west, between Ethâl and Wadi Usêt, the country is broken up by masses of gritty limestones, but its general character is that of an open, easily-traversed district, the wadi being bounded by low mounds, and rarely, if ever, having any distinct walls until near the Suez road, which crosses it about 5 kilometres from its mouth. At this point occurs a salt marsh with trickling streams of very brackish water, near which were a few stunted palms and tarfa bushes. The water is evidently thrown out from beneath the marls which occupy this hollow, by the hard limestone forming its floor. In winter a considerable quantity of water must occur here, judging from the quantity of salty mud lying around.

Below this the wadi begins to contract, and a little over a kilometre further down receives a small affluent, Wadi Krêt, which drains the eastern slope of Gebel Usêt. Beyond this junction it narrows rapidly and becomes a winding ravine 40 to 80 metres wide. About 2 kilometres further down, it narrows still more to a deep, wild gorge, cutting through the flank of Gebel Usêt. It is altogether impassable for camels, and very difficult for foot passengers; in many cases it is only 10 metres wide, and bounded by almost sheer cliffs of limestone of great height.

Wadi Ethâl impassible near the coast.

Returning to the Suez road where it crosses the wide, shallow syncline which lies between the Hammâm Farûn-Usêt range and Gebel Krêr, it is seen to skirt the east side of the salt marsh above-mentioned, and keeping along the bare, dry plain bears in a north-westerly direction towards Wadi Usêt. On the east it is bounded by a low ridge and mounds of marly beds, while its western side is formed by a low subsidiary escarpment of gritty limestone of a dirty brown, earthy colour capping the white limestones of Gebel Usêt. About 4 kilometres north of Wadi Ethâl, the water-parting between it and Usêt is reached; and about half a kilometre further on, is a shallow water-course which collects the drainage from the country on either side and carries it down into Wadi Usêt, 7.5 kilometres north of Ethâl.

Road between Wadi Ethâl and Wadi Usêt.

Wadi Usêt.—At the point where the road strikes this wadi there are one or two stunted palm trees as well as shrubs of gharqad, tarfa and retem, while just to the east of the road is a single palm, at the foot of which are some brackish springs, seldom used because of their proximity to the better supply in Wadi Gharandel. At this point the valley is broad and deep, descending through the maze of low hills from Gebel Krêr in which it takes its origin. Between it and Wadi Gharandel there lies a large mass of marls, etc., covered by a cap of gypsum.

Below the Suez road this wadi suddenly narrows as it enters the limestone ridge of Gebel Hammâm Farûn, cutting its way through the flanks of that hill by a picturesque gorge to the sea. This gorge, which is 3 kilometres long, winds its way between cliffs 20 to 30 metres high, the crest of Hammâm Farûn towering above it to the south. It is 20 to 30 metres wide, and its bed for a large part of the way is made of solid rock, water-worn and polished, and difficult to walk upon. At different points, too, the wadi takes a sudden drop over a hard ledge of rock, these various obstacles rendering it impassable to laden camels; while it is very difficult for heggin (riding-camels). About a kilometre

Wadi Difficult on account of small precipices.

from its mouth the wadi leaves the limestone, and opens out between low hills of marl and conglomerate, after which it debouches on the coast-plain and makes its way to the sea.

Hammâm Farûn-Usêt Range.

Having described these two wadis, the coast-range of Hammâm Farûn and Usêt comes next in order. This range extends from a point 2.5 kilometres south of Wadi Ethâl to the edge of Wadi Usêt, a distance of 12 or 13 kilometres. On its west side, towards the Gulf of Suez, it forms a sheer precipice up to the vicinity of the hot springs of Hammâm Farûn, the sea washing its foot, and not even the breadth of a path being left uncovered. It is thus impossible to observe this range from the west except from the sea. To the east the ridge falls away gradually, dipping about 10° in that direction, but gradually becoming less steep on the flanks of Hammâm Farûn.

Gebel Usêt.

On the southern half of the ridge, Gebel Usêt stands up in a well-defined, round, pointed peak, which is seen for a good distance in the country round about. It was used by the Ordnance Survey as a triangulation station on that account. In climbing it, the part at the top is very difficult, owing to the hard flinty limestone beds of which it is composed forming almost vertical ledges, on which footing was rendered very insecure by the quantity of angular gravel covering them. On its south side the hill falls away in a series of vertical cliffs towards Wadi Ethâl.

Gebel Hammâm Farûn.

The northern end of the above-mentioned range is generally known as Gebel Hammâm Farûn, but the Bedawin guides informed us that the whole range was really called Usêt. It forms a bold limestone bluff 479 metres high, facing the north-west and was used as a latitude and azimuth station by the Ordnance Survey. Here there occur several

Hot Springs.

hot springs which gush out at the foot of the cliff or even out of the sand itself. When approaching these springs from the north, a sickly smell of petroleum is discernable over a kilometre off, which rises from the water. The temperature of the water, according to the determination of the Ordnance Survey, is 160° Fahrenheit, or 71°C. The following is an analysis of the water taken from the Ordnance Survey Report:

Chloride of sodium.....	73.215 %
Sulphate of lime	6.720
Sulphate of magnesia	20.065
	100.000

Specific gravity at 60° F. 1007.3, water being 1000.
Amount of solid matter in the gallon, 1211 grains.

Near these springs is a cave in the rock in which the temperature is considerably over 100° F.; it is undoubtedly connected by a side fissure with that up which the water rises, and owes its temperature to the water. Outside the entrance the rock is covered with dried blood, and the Bedawin informed the writer that those who visited the springs for the purpose of using them as a cure for rheumatism, etc., brought a goat or sheep and sacrificed it to the spirit of the cave, as a propitiatory offering. These springs are called Hammâm Farûn Malûn (the Bath of Pharaoh the accursed) from a Bedawin legend which connects this place with the spot where the Egyptian host with Pharaoh at its head was overthrown and drowned while in pursuit of the Israelites. The hot springs are said to rise up the fissure which was made by the passage of Pharaoh to the nether regions.

Hot Cave.

Legend of the Springs.

Returning to the ridge, it may be stated that it is part of a large anticline which has been broken in the middle by the line of fault which gave rise to the depression of the Gulf of Suez. The hot springs in all probability are produced by the sea-water rising up some of the collateral fissures produced by the line of fracture.

Leaving the hot springs of Hammâm Farûn Malûn, a walk of 7 or 8 kilometres up the flat sea-beach, (here a flat sandy, and in places loamy expanse between 1 and 2 kilometres wide), brings one to the mouth of Wadi Gharandel. Here it is only 30 or 40 metres wide, and is bounded by steeply inclined cliffs of a gritty limestone. At the time it was visited, a good stream of slightly brackish water was flowing out of the wadi, and losing itself in the sand and gravel of the coast-plain. Further up, the valley widened and became practically one sheet of water, and recourse had to be had to a path running along the rocks forming the side, which a little higher up became impassable, and the party was driven back into the wadi once more. Its bed was one mass of bulrushes, reeds, and tarfa bushes which rustled in the wind.

Wadi Gharandel.

Running Water, Reeds Trees, etc.

As the Suez road was neared, the water gradually began to disappear, and groves of tarfa bushes, gardens, and palm-trees occupied the wadi. Signs were not wanting, however, to show that in winter even this part of the wadi was under water. At the point where the water disappeared from the surface of the wadi, it is joined by an affluent from the east, which drains the low country between it and Wadi Usêt.

All the way up to the point where the Suez road crosses it, the valley is one mass of tarfa and gharqad trees, amongst which one has to pick one's way. Near the road occur the wells which are dug in

the bed of the wadi. These were reported to yield excellent water, but experience did not bear this out. At the time of the visit, in the middle of March, the water had a full, goaty smell, and an unpleasant taste. The Bedawin stated, however, that it was always so in spring and summer when the water was scarce, but that in winter, during the rainy season, it was quite sweet and good. The sides of the valley from its mouth to this spot were composed of a greenish marly, or gypseous clay, which on the north side was capped by a bed of gypsum, but on the south had a covering of conglomerate and boulders. Near the wells the wadi is about 500 metres broad, and is bounded by low cliffs 20 to 30 metres high. Round the wells are several palms, and these continue, together with the tarfa and gharqad bushes, for over 2 kilometres up the wadi, the Suez road leaving it about this point.

Gebel Hoshera. Passing up the wadi from the place where the Suez road leaves the valley, there are no very well-defined sides to the water-way until Gebel Hoshera is reached. This is a ridge of gypseous marls and gypsum capped by hard coral and beach limestone on the north side of the valley, and difficult to climb on account of the vertical cliffs of the marls and the crumbling nature of the gypsum. From its summit a good view was obtained of the surrounding country. To the west, in the depression up which the Suez road passes, could be seen the green **Enqi el Fûl.** area known as Enqi el Fûl (the Bean field)—so-called because the Bedawin cultivate this area—which receives its water from the surrounding hills and retains it in a basin. Near the cultivated area were a few young palm-trees. On the south of the wadi rises the gypseous ridge of Gebel Gushîa from which descends an affluent—Wadi Gushîa—entering Gharandel opposite Gebel Hoshera. To the east can be seen the plateau of Gebel Abiad and Hiâla running back into the main table land of Gebel el Tî.

Returning to the wadi itself, from Hoshera it presents fairly good going, except for a few places where sand and gravel had accumulated. Along its course clumps of retem bushes occupied the centre, forming little islands round which the "sêls" (torrents) of winter had to pass, and against which they laid their burden of sand and boulders. Higher up gharqad bushes occupied the ground more or less to the exclusion of the retem.

Wadi Abu Qâda. From Hoshera eastward, the wadi undergoes a change of name and is now known as Wadi Abu Qâda. About 5.5 kilometres beyond the mouth of Wadi Gushîa, it receives from the north, Wadi Silfa (so-called because of its wide plain-like character), and about 1 kilometre farther on Wadi Um Retema enters from the south, both of them being short, insignificant watercourses.

About 8 kilometres higher up a more important affluent, Wadi el Abiad, heading in the plateau of that name, enters from the north, the main valley bending round sharply to the east past Gebel el Abiad. This is a tableland breaking up into ridges and isolated peaks near Wadi Abu Qâda, but assuming the characters of a plateau further north, with a slope to the north-west. It receives its name because of its dazzling whiteness, being composed of a white limestone, capped in places by a brown conglomerate. To the wadi it presents steep, vertical sides, up which it is difficult and in many cases impossible to climb. Wadi el Abiad

Beyond these hills where the country opens out somewhat, after passing the end of the ridge of Gebel Krêr which extends from Ethâl to this point, two affluents enter, one on either side, viz: Wadi Nasb from the north, and Wadi Hiâla from the south. Up the latter there is a footpath leading to Wadi Ethâl.

About 4 kilometres higher up, Wadi Um Silfa enters from the north, and the main drainage-line opens out into a wide, open wadi, which just at this point, changes its name to Wadi Wûta. This latter valley was not followed up further, but makes its way in a south-easterly direction through the El Tî plateau.

Leaving the main wadi at Um Silfa, a very bad road over ridges and rugged gullies was followed parallel with Gebel el Abiad and El Tî until the bed of Wadi Baqa (named from Baqa, a bundle of herbs, probably because of the number of plants around and in it) was reached. This may be regarded as the beginning of

(*b*) The beach plateau, etc., between Gharandel and Suez.

At the point where the southern branch of Wadi Baqa leaves the El Tî plateau, the connection between Gebel el Abiad and El Tî ceases, and a plain commences which extends from 29 to 30 kilometres along the foot of the El Tî plateau, being 14 kilometres at its widest from the foot of this table-land to Gebel Kahali (the hill of Kohl). It is covered with downwash in many places, but wherever this has been removed it shows a white chalky floor. Wadi Baqa.

The main Wadi Baqa comes down from El Tî, and is said by the Bedawin to head in that plateau three days' journey inland. There is good water up this valley. After leaving the plateau, it crosses the plain and receives its southern branch near the foot of Gebel el Abiad; between this point and Gebel Sanâfa, a small isolated limestone hill, it receives Wadi Um Rên, and El Abiad from the former plateau, and Wadi Um Adam from Gebel Um Adam, a continuation of the Abiad

plateau. This whole plateau slopes northwards and loses itself under the downwash of the plain.

Just at the end of the Um Adam plateau this wadi is joined by Wadis Melbe and Silfa, and a little further down, Wadi Darba, from the hill of that name, and the combined drainages make up Wadi Wardân (the valley which leads to the spring). In Wadi Melbe there is a well between 1 and 2 kilometres from its junction with Baqa.

Gebel Um Adam. As was previously stated, it is part of the same mass as Gebel el Abiad, and ends in a steep escarpment overlooking Wadi Silfa (the branch running north into Wardân); while it gradually bends round and falls away in a gentle slope towards the heads of the southern draining branches of Silfa and El Abiad.

Wadi Silfa. This is a valley with a soft sandy or loamy bottom which, near its junction with Baqa, (where it receives plenty of water from the hills on either side) is cultivated by the Bedawin. This wadi heads in a fairly wide plain, with mounds of gypseous marl in it, and receives the water

Wadi Amâra. from Gebel Um Adam on the east, and Ziêti on the west. Wadi Amâra also heads here, and passing through the ridge of Hoshera, makes its way across the open country past Gebel Amâra to the sea.

En Hawâra. From this point also, a road strikes south-west to En Hawâra, which is on the plain between Wadi Amâra and Gharandel, and about 11 kilometres from either.

Sikkat Amâra. From Wadi Silfa a path runs over the pass in the gypsum ridge which is a continuation of Hoshera, into the plain through which Wadi Amara passes, and is known as Sikkat Amâra. The country at this point is a mass of gypsum and gypseous marl covered in places by a cap of dark coral or beach limestone, while nearer the sea Wadi Amâra meanders among low mounds of sand and pebbles all the way to the coast.

Following the Suez road northwards, the way led across a low undulating plain dotted at first with a few low hills, and having a low plateau on the east, which, as Wadi Wardân is approached, gradually merges into the above-mentioned plain, sloping south and sending its drainage mostly into Amâra.

Wadi Wardân. Coming north across the plain which drains into Amâra, there is a gentle rise in the ground over some mounds of gravel mixed with calcareous and gypseous matter, and then a sudden descent into the wide bed of Wadi Wardân. On the south side it is bounded by steep low cliffs of gypsum capped by a conglomerate, while the opposite banks seem to be mainly composed of a gypseous conglomerate. At the point where the wadi was entered it was from 500 to 600 metres

broad, its bed being strewn with boulders, and cut up by numerous small watercourses which meander eastward amongst the bushes of tarfa, etc., which, together with bowwal and sakran, occupy the low mounds between them. After the last few days spent on the arid plain in the vicinity of Amâra, this sudden appearance of verdure was very welcome to the eyes.

Wadi Mas el Dhabba.

Opposite the place where the wadi was entered (a little above the Suez road), it receives from the north Wadi Mas el Dhabba (? haunts of the hyena) which drains the low, mound-covered plain on that side.

Gebel Halâfi.

Passing up Wardân, two small valleys were passed, (?) Um Demara, and Sia, which drained the plain to the north. After passing the last wadi the hill of Gebel Halâfi was reached. It consists of alternating beds of gypsum and gypseous marl, much cut up by narrow, deep-sided water-courses, which rendered climbing extremely difficult on account of the rotten crumbly character of these rocks. Forming the top was a hard, crystalline coral rock similar to that on Gebel Ziêti and Hoshera. This hill, together with those just mentioned, forms a ridge of gypseous hills capped by beach limestones, extending from the head of Wadi Gharandel to the foot of Gebel Raha, a distance of 34 kilometres. After leaving this hill the road led across a dull, uninteresting plain covered with mounds of loose gravel and white powdery calcareous or gypseous matter, in the direction of Wadi Tayiba.

Gebel Raha.

At the beginning of Gebel Raha (the flat-topped hill) the escarpment of El Tî ends, becoming fused with the plateau bearing the first name. This is essentially a later plateau which has been evidently laid on against that of El Tî and slopes gently westward, ending in a series of tongue-like extensions into the coast-plain, which has undoubtedly been produced by the denudation of its beds. It consists of a series of sandstones, sandy clays, and some limestone, through which several small valleys have cut narrow steep-sided beds which offer an effectual barrier to the traverse of an otherwise easy table-land. On the way north several small wadis were crossed near their exit on to the plain. These, beginning from the south, are Wadi Abu Hashîa, which drains the north side of Gebel el Alhala (a small outlier of the main plateau), Wadi Um Taset, Wadi Ibn el Fili, to the north of which comes Wadi Sadr. This wadi heads in Gebel Sadr or Taset Sadr, well inland in Gebel el Ti, the former being the watershed between a feeder of Wadi el Arish, and the valley which bears its name. The "sêl" of the wadi seems to be narrow and bounded by the high white limestone cliffs of Gebel el Raha, and after it leaves the

Wadi Sadr.

high limestone plateau, cuts its way through the secondary table-land to the plain. Up this wadi the Bedawin say there is good water, and a road leads up it past Taset Sadr to Nakhl.

Gebel Bisher. Beyond the low plateau of Raha rises the characteristic three-peaked hill of Gebel Bisher, a white limestone mass rising out of El Tî plateau, and a well-known landmark to travellers by land and sea.

Wadi Kahali. Before Wadi el Ahadha was reached the bed of Wadi Kahali (the wadi of the kohl-seller) was crossed. This wadi heads in Gebel el Raha.

Wadi el Ahadha.—This wadi, which is so named because horses can be brought thus far from Suez (from "hadhwa," the point of a horse's hoof), changes its name higher up its course, to that of Abu Kitâfa. It takes its origin in Gebel Raha, and after leaving the limestone plateau, cuts its way through another low tableland of marls, etc., down to the plain. On its north side and quite close to it is another —Wadi Naqa Gamîla—which receives the water from the low plateau of that name.

Gebel el Raha.—To the east, the line of view is bounded by the level plateau-like mass of Gebel el Raha which rises up from behind the low plateau forming its foot-hills. This range extends from Wadi Sadr up to a point to the north-east of Suez where it suddenly bends back and becomes lost to view.

Leaving Wadi el Ahadha and going in the direction of the coast, a bare, desolate plain dotted with low mounds and ridges is crossed, through which water-courses, marked by bowwal, rimth, sakran, etc.,

Wadi Dehêsa. make their way to the sea. Following the Suez road, the Wadi Dehêsa is crossed, so-called because of the mounds of sand in it. From this wadi northwards the road consisted of a score or so of parallel tracks where the ground was open, dwindling down to two or three where it passed through a narrow cut in a gravel ridge. All the way to Ayun Musa it was an alternation of wide, shallow water-ways separated by low ridges capped by a hard gravel conglomerate, through the gaps in which could be seen the palm trees, etc., which grow round the wells.

Ayun Musa.—Just before these wells are reached the ridges disappear, and the road enters a plain which is covered with shell-sand and fragments of various things met with on a beach. To the east of the wells is a low bank of oysters embedded in a mass of loosely cemented grit, while round about the springs the same sort of rock persists. The wells are in fact on a "raised beach area." They are situated in an indentation in the low plateau which lies around it and practically shuts it off from view from the south.

The Wells.

These springs are situated on a slight rise which falls sharply on its seaward side. It consists of what appears to be gritty material of the beach deposits evidently cemented together by lime deposited from the water. This rise is about three kilometres from the sea-coast and about fifteen from Suez. There are about a dozen springs of various kinds rising up through the rock, some of which are enclosed by a roughly-built wall, while others rise in natural basins evidently of their own formation, resembling a miniature cone and crater, some of which are full of rushes, while others have a clean basin. Some of the springs are utilised for irrigating the large gardens which have been planted, in which vegetables and fruit are grown for sale in Suez. Besides these springs there are a few water-holes which are only used for watering the camels, or washing purposes. Numerous palms and tarfa trees grow luxuriantly in the damp soil on the north side of the springs, forming a very efficient shelter from the wind and sun. Close to the gardens are one or two Arab houses occupied by the gardeners, and there is a more or less well-preserved Levantine house which is built in the form of a café or locanda owned by a Greek, who in company with some of his compatriots, live here and carry on a trade with the Bedawin who work the turquoise mines of Maghara, blasting-powder and other necessaries being given in exchange for the rough stones, which are taken to Alexandria and Cairo.

From the wells to the bank of the Suez Canal there are the remains of a carriage road said to have been made by Abbas Pasha, across the boulder-strewn plain which extends down to the sea. This is bounded on the east by a low plateau of clays or marls capped by a bed of hard conglomerate, from which many of the boulders on the plain have been derived. Before reaching the Canal, this plateau bends sharply round in a north-easterly direction, thus giving origin to the plain which lies to the east of the Canal.

To the east of the springs of Ayun Musa, this plateau is cut by Wadi Ayun Musa which comes down from the limestone plateau.

About 4 kilometres to the north-west of the wells are situated the Quarantine buildings of Ayun Musa, to which the passengers and crews of any ships having plague, cholera, or any infectious disease, are sent for varying periods before they are allowed to enter the Suez Canal.

(c) The Sandstone Plateau.

Having described the ground covered by the younger sedimentary formations in detail, it now remains to give an account of the country

covered by the sandstones and limestones of the Nubian series. While in the area just described the general character of the country was that of a plain bounded by ridges of uncoloured beach deposits or gypsum, or a low plateau of monotonous sameness without any features of interest to relieve it, with no trees and scarcely any verdure to refresh the tired eyes of the traveller, as a contrast the district to be described compares very favourably. The many and varied tints of the rocks, ranging from deep red and rich brown through yellow to pure white, furnish a never-ending and ever-varying kaleidoscope of colour effects, especially in the early morning at sunrise, and in the evening at sunset. It is at the latter time that the richest effects are noticeable, when the slanting rays of the westing sun, falling on the pink granite peaks, the jagged edges of the dark, gneissose ridges, and the dark-red rounded masses of sandstone, produce a gorgeous blending of colours shading from delicate rose tints to dark purple, which once seen can never be forgotten. Nor is this all there is to be seen; the wadis which drain this area present some very fine, steep-sided gorges of great beauty, along the bed of which numerous palms, seyal, tarfa, and retem trees flourish luxuriantly, offering very welcome shade from the rays of the noon-day sun; while the floor of the water-courses in the spring months, immediately after the winter rains, is in many places a veritable garden of flowers, and in their higher reaches, near the Debbet el Ramli, beds of lilies clothe the ground in a garment of bluish-white and pink, spangled with their long gladiate leaves.

This plateau may be said to extend from Wadi Ferân, in latitude 28° 48′ N., to the head of Wadi Hamr at latitude 29° 10′ N., thence running down to the west of the Debbet el Ramli to Wadi Siq and Gebel Dhalâl. From Wadi Ferân to Wadi Shellâl it is bounded on the east by high granite hills, and on the west by the Cretaceous ridge, Gebel Mokateb, Gebel Abu Alaqa, Wadi Budra, Gebel Markhâ, and Sarbût el Gemel, on the south by Wadi Shellâl, and on the north by Debbet el Ramli and Gebel el Tî.

At this point, it is not proposed to describe any of the wadis except those actually draining the area, those outside or only on the borders will be dealt with in the chapter on the igneous ranges.

Wadi Mokateb. Commencing then from the southern boundary on Wadi Ferân the first wadi to be noticed is Mokateb (the written wadi so called from the number of inscriptions found there). Leaving the above-mentioned valley, the road winds up through a rough boulder-strewn water-course draining south, and broken by low ledges of sandstone over which laden camels scramble with difficulty. After a walk of 3·5 kilometres

or thereabouts, the watershed is crossed and the true Wadi Mokateb is entered, which is a broad valley running down to the north between low walls of red sandstone, on which are carved the numerous inscriptions which give it its name. At its head it is practically an open plain with isolated mounds of sandstone; but later on these close up and form walls from 6 to 12 metres high, rising to 20 or 30 metres near its mouth. Near its origin it receives the Wadi Kateb from the south-west, and various other small feeders from the hills on either side on its way down to join Wadi Sidri. (For an account of the inscriptions see supplement to Part I, Ordnance Survey of the Peninsula of Sinai). In the bed of the wadi a few seyal trees are growing, and rimth is the main plant of the herbaceous variety.

At the point where it enters Wadi Sidri, the latter expands into a wide, shallow water-course—Sêh Sidri—in which are many seyal trees. From thence the wadi bends westward and running in a broad course between the terraced sandstone hills on either side, passes out through a steep-walled gorge at Abu Alaqa to the sea. The country around the Wadi Mokateb is practically a basin of low sandstone hills sloping down to Sêh Sidri, and overlooked by the commanding hill of Gebel Merzeqa on the east, and Abu Alaqa on the west; it has been faulted down to the west, as has the whole area up to Wadi Shellâl.

Wadi Qena.—About 7 kilometres down from the entrance of the Wadi Mokateb, Wadi Sidri receives from the north-east, Wadi Qena, which at its mouth is about 100 metres wide, and is enclosed by nearly vertical cliffs of soft sandstone between 70 and 90 metres high. About 1 kilometre from its mouth it receives the small feeder Wadi Qenaia in which occur the workings for turquoise in Gebel Maghara. The larger—Wadi Qena—bears north-east and immediately opens out into a wide. sandy plain containing many granite boulders and numerous well-grown seyal trees, the expanse ending against the granite range about 4 kilometres distant. In this range the wadi takes its origin, issuing from it by a narrow gorge.

Near the foot of the granite range is a well containing a perennial supply of good water, and said by the Bedawin to have been dug by Major Macdonald who worked the turquoise mines for some years. About half a kilometre above the entrance of Wadi Qenaia are the ruins of Major Macdonald's house, with the remains of what may have been a garden close by.

Wadi Qenaia.—This wadi runs for about 1 kilometre between steep-sided cliffs, then suddenly narrowing into a small gully breaks up into two, one branch—the shorter—bends north-west and after crossing a piece of low country ends in a precipice in a hill on the west; the other main branch holds a northerly course among low cliffs for 4 kilometres and ends at the foot of the granite range.

Gebel Maghara.—This is a more or less rectangular hill capped by a basalt flow. In it occur the workings for the turquoise. The following are the names of some of the workings in this and the neighbouring hills.

1. Zafarana: This occurs in the small triangle of sandstone between Wadis Sidri and Qena, and faces the former.

2. Hagaga: This is the most southerly one in Wadi Qenaia; of these there are four at present worked; the first is worked only on the face of the rock; the second has a short gallery which ends in a deep well-like shaft, as does also the third; while the fourth has a large working 12 to 15 metres high from which a short gallery has been commenced.

3. Yahudia, is said to yield the best stones and is worked along a short gallery.

4. El Rodd, is worked on the face of the cliff. Besides these there were two evidently ancient Egyptian workings which for superstitious reasons the Bedawin avoided.

These workings occur in the cliff from 40 to 60 metres above the valley, and are found over a distance of 200 to 300 metres.

Facing this is a small, flat-topped, conical hill lying in the angle between Qenaia and Qena on the top of which are the ruined houses of the miners and their guards. (For further description of this place with the hieroglyphics found there, see Ordnance Survey, Peninsula of Sinai, Part I, pages 167-180).

Leaving Wadi Qena, and following that of Sidri, the road winds between vertical sandstone cliffs for about a kilometre, when suddenly a boss of granite appears on the left, rising up into sheer precipices and pinnacles, and lending grandeur to the scene. This has evidently acted as an obstruction to the water, as it runs parallel to its length and has made its way round the end of it, bending sharply back to its original direction and holding on its way past the mouth of Wadi Budra to the sea.

Sheikh's Tomb.

Opposite the mouth of Wadi Qena in Wadi Sidri, there is a sheikh's tomb at which the Bedawin pay their devotions.

PLATE II.(a)

NAGB BUDRA

PLATE II.(b)

LOWER PART OF WADI FERAN.

Turning to the right out of Sidri, Wadi Budra is entered about 3 kilometres below Maghara. This is a fairly wide valley which rises rapidly to the north, and soon divides into a number of branches which lose themselves among the steeply-inclined ridges of sandstone. On the west it is bounded by the steeply-tilted Cretaceous marls, and on the east by the edge of the sandstone plateau. The bed of the wadi is clothed with bushes of rimth and shia, while seyal trees occur here and there. After the wadi breaks up near its head, the path wanders about amongst low hills of vari-coloured sandstone and shale, ranging from yellow, red, purple, to blue, until after about 3 kilometres it reaches the pass known as the Naqb Budra. This is a sudden drop into the basin of Wadi Shellâl, and is negociated by a winding path which crosses and recrosses the side of the pass; here and there the path is strengthened by a loose wall; while at other places the camels have to slip and sprawl over rounded knobs of sandstone. Wadi Budra. Naqb Budra.

On the left is Gebel Naqb Budra which presents a piece of fantastic sculpturing in the sandstone which forms its base, above which succeed successive terraces of limestone and marl to its summit, from which a fine view of the surrounding country is obtained. Looking eastward the sandstone is seen to consist of a massive plateau cut up by narrow, steep-sided wadis, and having patches of basalt dotted about on the higher summits. Towards Wadi Shellâl it slopes down quickly and has undoubtedly been let down by a fault against the granite on the north of the valley. After descending the Naqb Budra, the road leaves the wadi of that name, and crossing the heads of one or two small water-courses descends rapidly towards Wadi Shellâl. The ground passed over consists of sandy shales and sandstones of many colours, and is covered with a ferruginous slag-like gravel derived from the sandstones of the plateau. The road on entering the Wadi Shellâl runs for about 2 kilometres in a direction west of north until it reaches Wadi Baba, from whence it turns west into Sêh Baba and El Markhâ. Gebel Naqb Budra.

Leaving the road at the junction of the two above-mentioned valleys it is now necessary to give a short account of Wadi Shellâl as far as it is known. Wadi Shellâl.

From its junction with Baba, as stated above, its "sêl" lies along a west-of-north line, having a width of 100 metres or so, and a fairly smooth bed covered with soft sand which makes heavy going. On the east, it is bounded by hills of dark green gneiss capped by red sandstone and brown limestone, which show a terraced appearance due to step-faults; while its western side is formed of steeply-tilted beds of Cretaceous marls and Nubian sandstone. At the point where the

camel path to Naqb Budra leaves it, it takes a sharp bend eastwards and 2 kilometres higher up receives Wadi Budra, and half a kilometre further on Wadi Abu Aqîla from the south. Up to this point both sides are formed of the red sandstone and limestone of Carboniferous age, which between the entrance of these two wadis form a cataract about 6 metres high, owing to the limestone crossing its bed. (It is probably from this that the wadi receives its name "Shellâl" meaning cataract.) Passage to the upper part of this wadi is obtained by a rough camelroad winding up its north side. Above the cataract the valley opens out into a wide bed in which the Bedawin encamp in the early spring with their flocks, water being reported higher up at a place marked by a few palms. Above the cataract the wadi was not explored ; but from the surrounding hills it was seen to enter the granite and gneiss hills by a narrow gorge, and its head was not very far above that point.

Inscriptions. On the sandstone and limestone immediately below the cataract several Sinaitic inscriptions were noticed.

Wadi Baba. Returning to the mouth of Shellâl it is now necessary to go up the Wadi Baba in order to see the country from the best stand-point. At its mouth this valley is about 200 metres wide owing to its junction with the Wadi Samra, and also to the sudden arrest and replacement of the igneous and metamorphic rocks by limestone and marl which weather easily.

Just by the mouth of Wadi Samra is a small hill of red granite, which makes a striking contrast with the dark-green and gray gneissose rocks forming the hills at this point with their caps of red sandstone. They rise up sharply from the plain, towering peak over peak in all their rugged grandeur. Immediately on entering the hills the valley assumes a very tortuous course, bending and twisting in a most remarkable way through as fine a gorge as any in the peninsula. In places the bed of the wadi is no wider than a path, a laden camel having very little room to spare on either side ; while again it opens out a little only to close in once more. Its floor is strewn with huge boulders of granite ; while numerous small ledges occur over which the camels have to clamber. On either side the granite hills rise in precipitous cliffs of over 300 metres in height, while they tower away peak above peak for over 300 metres more. Down the sides of these hills, during a rainstorm, pour numerous small tributary streams, some of them falling over cataracts 100 metres high. The scenery here is of the grandest and most savage description, the hills closing in so that the wadi is in perpetual shadow, while into some of the sharp bends the sun never penetrates.

In nearly every little side valley there are rock-basins containing water, but inaccessible, except to men who can climb the slippery, polished rocks in the way. Palms, too, are present here and there where the water occurs near the mouth of the tributary wadi.

For 5 or 6 kilometres the valley continues its tortuous course, and then the hills, which have been gradually becoming lower, open out, and little by little the gneiss and granite become covered up by sandstone, and disappear below ground. This is an exceedingly dangerous place to be caught in during a rainstorm, as the wadi has an extensive collecting ground, and in the confined space of its lower reach the water must rise at least 20 metres, judging by the appearance of the rocks on either side.

Running water, Palms, etc., in Wadi Baba.

From the point where the wadi began to open out, running water was met with which occasionally disappeared in the sand only to reappear again at another point. Numerous palms and tarfa trees grow luxuriantly where this water flows. The character of the water is poor, being brackish and undrinkable. For 5·5 kilometres or thereabouts, this water is met with and the palms seem to accompany it, but a little above the mouth of Wadi Hamât they disappear.

Wadi Khallîq.

About half a kilometre above the entrance of Wadi Hamât, is that of Wadi Khallîq, a small wadi draining the low hills to the north. In it occur one or two "maghara" or mines, in which manganese and iron ores occur about a kilometre from the mouth. Opposite its junction with Wadi Baba there is an Arab burying ground.

Mines.

About 2·5 kilometres higher up the Wadi Baba opens into a wide sêh, or plain, formed by the junction of four drainages, viz., the two branches of Baba from the north-west and north, the latter receiving Wadi Bêda from the Debbet El Ramli, and Wadi Nasb and Suwiq. From this point, looking westward, the country is seen to be a plateau sloping towards the east and north from the high ridge forming the boundary of El Markhâ and the granite and gneissose range away to the south which forms the watershed between the feeders of Wadi Sidri and Baba. It is essentially a sandstone country in appearance, showing the flat-topped hills separated by the narrow, vertical-sided gullies so common in such an area.

Wadi Nasb.

This is one of the most important feeders of Wadi Baba. At its mouth it is a shallow water-course about 100 metres wide, bounded on the west by cliffs of sandstone only a few metres high, while on the east the same rock rises 60 to 90 metres above the floor. The explanation of this is that the country has been let down by a fault to the west, along line whose the valley has formed. About 2·5 kilo-

metres from its mouth, gneiss appears at the foot of the eastern cliff and continues up to its head. Along the bed of the wadi numerous well-grown seyal trees occur, which were probably grown in much greater numbers by the ancient miners for the supply of the charcoal for the smelting of the ore found in the vicinity.

About 5 kilometres from its mouth there are the ruins of a village with large heaps of copper slag. Close by are one or two gardens in which are a few palm and sidr trees, and two or three springs from which the gardens and a little of the surrounding land are irrigated by means of shadufs. Near by are several caves or galleries, probably made in search of ore though some may have been occupied as dwellings.

From the ruined village a path strikes off across the ridge towards Serabît el Khâdim. Several other paths start off from this point to the old workings which occur all over the plateau.

Wadi Suwiq and its tributaries.

Leaving the mouth of Wadi Nasb, the path leads up Wadi Suwiq towards Serabît el Khâdim. On the left it receives the small affluent Wadi Ikfa which heads on the edge of Debbet el Ramli, and on the right, 1.5 kilometres from its mouth, Wadi Lahiân, a long, broad, steep-sided water course which heads about 7 kilometres to the south. Between this and the next important tributary on this side—Wadi Bala—are two unimportant feeders, Wadis Zebêr and Nimla.

Wadi Bala.

Wadi Bala which enters from the south about 4 kilometres above Lahiân, is a fine broad valley cut in gneiss with the sandstone capping it on either side. Like the latter it has a plentiful growth of seyal trees in it.

Wadi Habûs.

From the left entering opposite Wadi Nimla comes the important affluent Wadi Habûs which drains a large piece of Debbet el Ramli, its continuation being the Wadi Garf. About a kilometre further on Wadi

Wadi Merâq.

Merâq enters from the east from its source in the sandstone hills bordering Debbet el Ramli. This valley is so called because of the broad, meadow-like expanse near its mouth. Round it a good deal of blown sand has been accumulated and consolidated, and now yields a certain amount of pasture for the flocks of the Bedawin who have an encampment there. Near here was the home of one of the sub-sheikhs of the Towara, Modakhal Suliman.

Wadi Suwiq ends in a Naqb from which it descends steeply at first, flowing primarily in a north-westerly direction and then bending round to the west. It is bounded by the vertical cliffs of the Carboniferous sandstone, and winds about a good deal on its way to join Wadi Baba.

In a small wadi west of Habûs there is a deep well dug in its bed and properly pitched, which yields a fair supply of brackish water. The name of the wadi is Melha.

Serabît el Khâdim.

Having put down the camp for a day at the mouth of Wadi Serabît el Khâdim, an ascent was made to see the ruined temple which is on the top of the plateau. Leaving the camels, a path was followed up the wadi for a little, and then it began to wind slowly up the hill ledge by ledge until the plateau was reached. This temple has been fully described in the "Ordnance Survey of Sinai," Chapter VII, pp. 192-3. Here there are some old workings for turquoise which are said to be exhausted, any stones now found being worthless.

Gebel Serabît el Khâdim.

Climbing the hill behind the plateau on which the ruined temple stands a good view of the surrounding country was got for tens of kilometres round. The hill itself is roughly rectangular in outline with its longer axis lying north-west and south-east. The sides are very steep and difficult of ascent, this being largely due to its having a cap of basalt which, acting as a protective covering, yet allows of the weathering of its sides. To this is to be attributed its greater height above its immediate neighbours. Falling off in a south-westerly direction is a tongue which runs up to the base of Gebel Tatar el Dahami, a granite mass whose summit is composed of a col of sandstone; while to the south the gneiss country is seen spreading out on either side of Wadi Um Agraf. To the east the course of Wadi Siq is seen, as it meanders its way down from El Tî, the whole of which escarpment is visible as a wall extending from Gebel Dhalâl to the head of Wadi Hamr, with the plain of El Ramli lying at its foot. To the west, in the immediate foreground, stand up the two well-defined peaks of Gebel Um Riglên (so called because of their resemblance to two legs); while the sloping sandstone plateau is seen rising up to the heights of Gebel Baba, and sinking to earth to the north beneath the sand of the Debbet el Ramli, the wadis appearing like open drains at intervals in it.

Naqb Suwiq.

From the mouth of Wadi Serabît el Khâdim the path leads over the Naqb Suwiq, (which is impassable for laden camels, and difficult even for heggin) into Wadi Khamîla. This latter wadi will be described along with Wadi Um Agraf of which it is a tributary.

There now remains to be described the piece of sandstone lying between Wadi Siq and Gebel Dhalâl. Between these two places there is a difficult path over the rough sandstone ledges which leads to the head of Wadi el Akhdar. In this area the combined action of wind and sand are well seen. Here also is met with for the first time a pure white sandstone which dazzles the eyes, and is worn into most fantastic

shapes round the foot of Dhallâl. Looking from the west at this hill and its continuation of Gebel el Tî, there is a series of terraces and buttresses alternating up to the base of the limestone cliff which are wonderful in their variety. The contrast, too, between the white and dark-red sandstone is very striking, and the way that the white caps the other gives the impression, from a distance, of banks of snow resting on a brown floor. The brown variety runs out it an irregular manner on to the igneous rock behind, this being due to its unequal removal by the weathering agents.

Much sand has accumulated at the head of Wadi el Akhdar and when this place was visited about the end of February it was covered in many places by beds of lilies.

3.—THE MAIN MOUNTAIN MASS.

Having now finished the whole of the sedimentary area, it only remains to describe the large mass of igneous and metamorphic hills which extends from a little to the north of Wadi Um Agraf and Wadi Sidri to the neck of Ras Mohammed. In the introduction it was proposed to divide this district into two, viz. (*a*), that north of Wadi Hebrân, Solâf, and Gebel Gharbi, and (*b*), the district to the south of that line.

This division will still stand but instead of describing each district as a whole it will be taken wadi by wadi and the country seen on each side with the tributaries flowing into it will be described as they are passed, while a general summary of the salient features of the district will be given at the end.

a) Country north of Wadi Hebran.

Wadi Siq.—Commencing from the north this is the first main drainage of the district. Rising in the plateau of El Ti, it flows west for 5 kilometres along the foot of that escarpment and for 5 kilometres more in a wide course through an open sandstone plain, at this point receiving its first affluent, Wadi Shêqer, (so called from its brownish clay colour, "shêqra," clay) from the low hills on its left bank.

Wadi Shêqer.—This wadi, where it enters Wadi Siq, is very wide, the country being practically a plain. It takes its origin at Naqb

Shêqer, a difficult pass which takes the best part of an hour to walk over on foot, and for camels considerably longer, it being only practicable for heggin. Its whole course is in gray granite with outliers of sandstone dotted about here and there upon it, its total length being 12 kilometres. About 3.5 kilometres from its mouth it receives from the east an important feeder, Wadi Berq, which rises in the sandstone hills at the foot of Gebel Dhalâl. For three kilometres it runs through the plain in which Siq is, and then enters the sandstone; in 2.5 kilometres more it changes its name to that of Gharbi, a small branch from the north, taking that of Berq, and 4 kilometres further on it heads in the foot-hills of the above-named hill. For practically the whole of its course it runs more or less parallel with that of Siq. Water is plentiful in Shêqer and Gharbi.

Wadi Berq.

Wadi Gharbi.

Returning to the mouth of Shêqer and resuming the course of Siq, about two kilometres further down the mouth of Wadi Um Bassal is passed, a short valley which drains a small open plain into which Wadi Enqaib enters.

The small plain above-mentioned is a curious example of the kind of watershed met with in this high plateau; it differs thus from those lower down where the parting is marked by some very abrupt line of division in the shape of a rugged ridge or dyke.

From Wadi Um Bassal there is a path over a low pass into Wadi Entish (named from a plant natesh or latsh which camels eat) which enters Siq six kilometres below Um Bassal. This wadi is bounded by steep sides of gneiss which shut out all view from the north as by a wall; but the bed makes excellent going, and supports numerous plants which yield food for the camels.

Wadi Entish.

About a kilometre below Entish, Wadi Siq receives an important tributary, Wadi Monia. This wadi transgresses considerably on the basin of Wadi el Akhdar; it rises close to the head of Wadi Esh, and drains the east side of the granite mass of which Gebel Hamra is the highest point, and the flat-topped metamorphic plateau extending from it to Wadi Siq. At its origin it takes the name of Wadi Bum, and flowing north-east for 5 kilometres until on a level with Naqb Shêqer, bends round to the south-west towards Siq, then takes the name of Monia, and has a total length of 23 kilometres.

Wadi Monia.

Wadi Bum.

From this point onward, Wadi Siq has a firm sandy bottom; it has the open plain of El Ramli on its right for about 5 kilometres; after which it enters the sandstone plateau with gray granite at its base, having almost vertical cliffs on either side, while its left is furrowed by narrow, steep-sided gullies which drain the plateau to the south. About

10 kilometres from Entish the mouth of Wadi Tayiba is reached; here Wadi Siq bends sharply north about a kilometre and then turns once more eastward. Opposite the mouth of Tayiba there is a sudden widening of the valley caused by the junction at this point of Wadis Sheikh Ahmed and Maraikh, the former being named from a Bedawi saint whose tomb is there, while the latter is named from Markh, plural Maraikh. Both of these affluents are short, wide wadis, down the former of which comes the path from Serabît el Khâdim to the Dêr at Gebel Musa, while the latter drains the plain of El Ramli. In this small plain a little piece of the loamy sand has been enclosed and is cultivated by the Bedawin.

Wadi Tayiba. Wadi Tayiba at its mouth is a fairly broad valley with a somewhat rocky bottom, covered with a fair amount of vegetation and having some very well-grown seyal trees in it. Two and a half kilometres up it bifurcates, the branch bearing its name running off to the south where it heads near Gebel Tayiba, a distance of 7 kilometres from the fork, and near which is the origin of Wadi Nisrîn. The other branch, Wadi Barraq. Wadi Barraq or Barq (so called because a Bedawin encampment was here destroyed by lightning) bends off to the south-east, and is a fairly wide valley, about 80 metres broad, and has a very rough stony bottom. Several well-grown seyal trees are found here. About three kilometres from its mouth the last of the sandstone is seen; and immediately beyond this enters, the tributary, Wadi Ibn Sakkar, up which good water is said to be found. From this point, the sides are composed of metamorphic rocks in which many dykes and veins are seen, and as the head of the wadi is neared the road becomes extremely rough and stony, finally ending in a rough path over a small ridge until the plateau is gained. Here there were some nawâmis, (i.e. ruins of houses, etc., of the ancient inhabitants). The total length of the wadi is 10 kilometres. Up this valley goes the path to Gebel Musa.

Returning to Wadi Siq, at the junction with Wadi Sheikh Ahmed and Maraikh, the former widens out into a narrow plain called Sêh Barq. On the left bank is a high cliff of quartz-felsite, with sheer sides facing the wadi, which forms the edge of the plateau of Fersh Abu Alaqa from which a good view of the surrounding country can be obtained. Looking north, the great plain of El Ramli stretches away to the bounding wall of El Tî; while to the east and south, a flat-topped, sloping plateau is seen rising with a gentle inclination from the base of El Tî towards the high ground in the neighbourhood of Wadi Fêran and Serbâl, dotted with a few outliers of sandstone,

but beyond these having no salient features to vary the monotony of an otherwise featureless tableland, and recalling very vividly to the mind the description of a "plain of marine erosion" which this has undoubtedly been. It is nevertheless divided into areas named after the wadi draining them, as for instance Fersh Sidri, Fersh Nisrîn, etc. To the west and north-west can be seen the peaks of the gneiss hills overlooking Wadi Mokateb, the granite hill of Gebel Merzeqa, and its extension to the Gebel Tâtar el Dahami, while sweeping round towards Serabît el Khâdim is the edge of the sandstone plateau resting on the gneiss which forms the whole of the country to the west. Immediately below can be seen the small triangular patch which is bounded by Siq, Wadi Sheikh Ahmed, and Khamîla, the latter of which is next to be described.

Wadi Khamîla

This valley, so named because of its sandy bottom, takes its origin near Naqb Suwiq, and after flowing south-east for 8.5 kilometres, bends sharply round and flows to the south-west for other three kilometres, when it enters Wadi Um Agraf, (the continuation of Siq); the latter name is apparently only given to the upper part of the main wadi. Khamîla, at the point where it changes its course, receives another short branch from the south-east from Debêbat Sheikh Ahmed.

Wadi Um Agraf.

About four kilometres below the entrance of Khamîla the Wadi Um Agraf itself enters Wadi Siq from the north-east. It heads near the base of Gebel Serabît el Khâdim, and flows south-east in a steep-sided bed in gneiss capped by sandstone, finally turning to the south-west and entering the main valley. From about this point it becomes clothed with a carpet of many-coloured flowers in the spring time, its sandy and loamy bed being suited to the growth of these plants. Seyals grow in abundance, too, and altogether this wadi is one of the pleasantest of those traversed. The walking is excellent, good firm footing being always to be had, while the rough patches of boulders can always be avoided. This character is maintained the whole of the way to the entrance to Sêh Sidri.

Below the entrance of Wadi Um Agraf, the main wadi assumes a very tortuous course, winding about like a huge snake, and receiving only the unimportant affluent of Wadi Biyut (the valley of houses) from the gneiss hills on the right, until it reaches the entrance of Wadi Sidri. On either side the country has lost its plateau-like character; it is more broken up and diversified by ridges and peaks, especially on the right; but on the left this character only holds in the immediate neighbourhood, its southern boundary being Wadi Um Fêh which

separates the broken ground of Gebel Um Fêh from Fersh Sidri, a part of the main plateau described above.

Wadi Sidri. After winding about for about 7 or 8 kilometres Wadi Um Agraf enters Wadi Sidri which comes from the south-east. The latter is a fine broad wadi studded with numerous seyal trees. It rises in Fersh Sidri, flows west of north for 3 or 4 kilometres, then bends sharply to the west at the point where it receives Um Fêh and continues this course with but little deviation till it leaves the hills. A little further on, it receives the small tributary Wadi Dâma from the right. From this point the wadi passes through granite, the culminating peak of which is Gebel Marzeqa, a fine commanding height overlooking Sêh Sidri and Mokateb.

Wadi Neba. On its south side enters Wadi Neba, a small drainage in which water is said to occur. At its mouth were a few stone huts which the guides said were used for storing corn when a consignment was received from Suez. This the Bedawin were busy doing when the writer passed this place.

Leaving this valley, the next to be described in detail is Wadi Ferân. Starting from the point where the small branch of Mokateb enters it, Wadi Ferân. and going up the wadi for about 2·5 kilometres, the mouth of Wadi Nisrîn (valley of the eagles), the first important feeder from the Wadi Nisrîn. north side is reached. This valley takes its rise away up in the plateau near the head of Wadi Tayiba in Gebel Tayiba, and flowing west receives the drainage from Fersh Nisrîn, after which it sweeps round the base of a red granite hill, and passing along amongst the low mounds of gray granite which occupy the space between that hill and those of gneiss overlooking Wadi Mokateb, passes out in a south-westerly direction into Wadi Ferân. At its mouth some stone circles occur. From the mouth of Wadi Nisrîn, Wadi Ferân goes up in long, open reaches 300 to 500 metres wide in places, the floor being made of clean granite and gneiss gravel well packed and easy to walk on, while rimth and shia occupy the sandier parts, and well-grown seyal with occasional tarfa trees are studded all over its course.

About three kilometres above the mouth of Wadi Nisrîn the sedimentary rocks cease, their boundary being marked practically by the course Wadi Nidîa. of Wadi Nidîa (moist valley), which enters here from the south from its source in the limestone hills. The contrast between the metamorphic rocks and the sandstone which is here laid against them is very striking; the former have a dark-green, sombre colour, while the latter has a rich, warm brown. From this point the road lies between gneissose

rocks, those especially on the north side rising steeply in sharp, jagged ridges which often culminate in a conical-shaped crest, and in many cases offer sheer precipices to the daring climber which baffle his boldest attempts. On the south side the same character is seen, but on a much smaller scale. The hills are here veined and dyked in a wonderful manner by various kinds of rock, the principal of which are dolerite and quartz-felsite. It is higher up, however, beyond the oasis that this phenomenon is seen at its best. There the dark-green, gneissose ridges are crossed by hundreds of dykes and veins, the red felsite predominating, and only separated from each other by one metre or less, while they cross and interlace in the most wonderful manner. In other places, dolerite and felsite alternate, the warm, dark-brown weathering of the former contrasting well with the brick-red of the latter. In many cases the ridging of the gneissose hills is due to the presence of a hard dyke. On the south side of Ferân in some of the small wadis such as El Tarr, some beautiful examples of folding are seen in the gneisses, the folds being marked by alternate layers of black mica and white quartz and felspar.

Wadi el Rummâna.

About 2 kilometres above the mouth of Wadi Nidîa there enters from the north-east the important tributary of Wadi el Rummana (the valley of the pomegranate) which will now be described. This is a fine, broad valley studded with seyal trees, having its bed made up of clean, well-packed granite and gneiss gravel which affords good footing. About a kilometre from its mouth, there enters from the north the Wadi Darqîd which heads in a red granite boss, from which a good view of the district is obtained. Standing on this hill, looking east, the Fersh Nisrîn with the wadi is well seen on the north side, a splendid bird's-eye view being obtained of its course; while away to the east, over the ridges of gneissose, gray granite, could be seen the head of Wadi Aqr and its junction with Wadi Lebwa; to the south-east rise the plateau of Yena, Gebel el Banât and Gebel Goze, the two latter being seen for a long distance from every side, and easily recognized by their dark-red colour and peculiar rounded summits; and still more to the south rise the red peaks of Serbâl in all their rugged grandeur, set as it were on a base of dark-green gneiss.

Across the hills at the foot of this ridge, red dykes run in a north-easterly direction, and can be seen extending for kilometres away. From this hill it is very difficult to find a way down, all the water-courses ending in precipices; while the sides are very treacherous and rotten. In the wadis, water occurs here and there in holes at the foot of polished water-falls which have to be negociated in a sitting posture; while

farther down one has to thread one's way amongst huge boulders, thousands of kilos in weight. In the sand amongst these boulders, hamad, a succulent plant of the genus Rumex, grows in great abundance, and is collected by the Bedawin for their camels who eat it with every sign of relish. Asphodels also grow in abundance in the wadis.

About 2·5 kilometres from the mouth of Wadi Darqîd, the valley bends round to the north-east, receiving a drainage from the vicinity of Gebel el Banat, and zigzaging about, receives several small tributaries from the north, among the most important of which are Wadi Hallâl from Gebel Hallâl, Wadi Ganûs which drains the high ground to the north, and Wadi Ekba from Gebel Ekba, a small boss of syenite which presents a precipice of over 100 metres in height. Further up about 3·5 kilometres above the bend to the north, the wadi makes a sigmoid twist and shortly afterwards changes its name to that of Rahaba (the expansive valley). All the way up the valley the hills preserve the same character, viz, that of a plateau much cut up by dykes, and short, steep gullies which run rapidly to the top of the table-land. From the sigmoid flexure, the wadi continues with very little deviation in a north-of-east direction until it reaches its junction with Wadi Aqr, (Akhdar of the Ordnance Survey). Wadi Rahaba keeps its eastward course and opens out into a plain near its head, the ground being covered with heaps of granite debris, and low mounds of granite. From this plain there is a rugged pass through a narrow granite ridge, consisting of a series of steps, up which the camels have to clamber very carefully. This pass is impracticable for baggage camels.

Wadi Rahaba.

Wadi Aqr.

Returning to the Wadi Aqr, its course is for the first three kilometres, slightly west of north, after which it bends sharply round almost due east, turning again sharply north to its head near that of Wadi Barraq. Round its course the country is open and the hills are low, at its head being only a few metres high. As it descends rapidly they soon increase in height, but there is a sameness about them which amounts to monotony.

Wadi Lebwa.

At the head of Wadi Aqr, the country to the south-east, owing to the denudation of the red granite, opens out into a sandy plain five kilometres wide, clothed with retem, shia, and other desert plants. Here again the same phenomenon was seen as was noticed in Khamîla, viz. the flowing of two lateral valleys to meet each other. From the north-east comes Um Retema draining the low hills in that direction; while Wadi Lebwa receives Wadis Dhenêb and Hanêk and one or two more small tributaries.

Um Retema.

Wadi Lebwa can scarcely be called a wadi as it is merely a drainage

line across this plain; it begins near the head of Wadi Barra (which runs to El Akhdar), where the watershed is scarcely noticeable.

Wadi Rahaba and Rummana seems to be a very important valley judging by the number of Bedawin encampments seen in it, and the number of sheep, goats and camels grazing in it. The valley itself yields good fodder; and as there is not much difficulty it getting on to the plateau the supply of forage is practically inexhaustible. The water supply is good, water being found in nearly every little valley which comes down from the plateau; and the presence of numerous well-grown seyal trees all down the wadi, shows that water is present in its sandy bed not far below the surface. That it is visited by heavy storms is evidenced by the deep ruts cut in its bed, and also by the big mounds of boulders which are heaped up here and there, making the upper reaches of the wadi rather rough going.

Returning to the mouth of Wadi Rummana, and going up Ferân for about two kilometres, the mouth of Wadi Bashîh, a considerable tributary is reached which, heading in the gneiss close to the valley of El Tarr, runs north for 6 kilometres and empties itself into the main valley. Wadi Ferân. Wadi Bashîh.

As Ferân is ascended, the mountains forming its sides become higher and wilder, and gradually close in, the bed of the wadi becoming much narrower. Strong evidence of the resistless force of the torrents is seen in the huge masses of detritus piled up in the side valleys and at their mouths, and which have been cut through in a wonderful manner, leaving vertical sides 20 to 30 metres high.

In Wadi el Tarr these are seen at their best, vertical mounds of limestone pebbles standing on the sides as high as 30 metres above the valley. In many of these side wadis may be found a Bedawi and his family with a goodly flock of sheep and goats, the latter predominating and numbering as many as 50. Up this valley one catches glimpses of the limestone plateau behind, the last glimpse being got as the mouth of Wadi el Gabari is passed. Wadi el Tarr.

Opposite the entrance of Wadi el Tarr, from the left bank, is the mouth of Wadi Qosêr, (the short valley) a wide, rough-bottomed valley in which many well-grown seyals are seen among the granite boulders. Up it a glimpse of Gebel el Banât is first observed; but it is not until Wadi Um Fus is reached that a full view of this striking hill is obtained. To the west, it presents an almost precipitous front, impossible of ascent; while it towers up in a high conical summit far above the surrounding hills. Its rich colouring, especially when bathed in the rays of the setting sun, is wonderful, and not soon forgotten, completely eclipsing anything seen in any other part of the peninsula. It receives its name Wadi Qosêr. Gebel el Banât.

from a legend current among the Bedawin, that two girls who had been promised in marriage to two men whom they did not like, fled there, and when pursued, rather than marry against their inclination, threw themselves over the precipice mentioned above and were dashed to pieces.

Wadi Um Fus. This is a considerable tributary which receives all the drainage from Gebel el Banât, as well as some from the plateau of Yena which lies to the east. From the mouth of this wadi, the hills on either side are so close and their sides so steep that they cut off all view of the neighbouring range of Serbâl.

Gebel Serbal General Description. The main topographical features of Gebel Serbâl are described in the following letter of Captain H. S. Palmer,* R.E.:

" Feiran February 2nd, 1869.—Our camp here is pleasantly situated, at the junction of Wadi 'Aleyat and Wadi Feiran, and close to the oasis of Feiran which terminates just at this point. . . . Jebel Serbal is about four miles from the camp. In massive ruggedness and in boldness of feature and outline this mountain certainly presents an aspect unequalled by any other in the peninsula, and, though not absolutely the highest, it has a greater command over the surrounding country than any we have so far seen. Unfortunately there is hardly a single point in the valleys near its base (on this side at all events) which affords a really comprehensive view of the mountain. It is only by ascending some of the neighbouring hills that the whole range of its magnificent peaks can be seen at once, and there is no plain anywhere in the vicinity suitable to the assembling of a large concourse of people in sight of any one portion. Two unimportant valleys, Wadi 'Aleyat and Wadi 'Ajeleh, each from three to four miles in length, rise from Feiran to the actual base of Serbal, and furnish the roughest examples we have yet experienced of the very rough walking in the peninsula. Each—and especially Wadi 'Ajeleh, the western and narrower valley—is a wilderness of boulders and torrent-beds and high banks of alluvial deposit bearing the marks of many a *seil*. From points in these two valleys, and from a few spots also in Wadi Feiran, partial views of Serbal may be had, but from Wadi 'Ajeleh the highest peak is never seen. The space between the two, which I think has been described as a 'plain,' is a chaos of rugged mountains, rising to as many as 2,400 feet above Wadi Feiran, and concerning which our boots and knees could tell a very different tale.

* "Ordnance Survey, Peninsula of Sinai," Vol. I., Chap. III., pp. 89-94.

" There is, however, a third valley, Wadi er Rimm, not mentioned in my letter, which receives the drainage of the north-eastern slopes of Serbal, and flows eastward to meet Wadi Feiran at a point about seven miles above Paran. This valley, in its main characteristics, closely resembles Wadi 'Aleyat and Wadi 'Ajeleh, though its course is much more crooked. I find its lower part described in my journal as 'about a hundred yards broad, winding and extremely rough, with high dyked mountains on either hand; the only tolerable walking to be found is in the tortuous bed of the water channel.' Three miles from its mouth, the wadi, approaching the foot of Serbal, is reflected sharply to the south-east, and just here there is a fine view of part of the crest, including the highest peak, and of the eastern cliffs of the mountain, which rise in stupendous majesty above this point. Wadi er Rimm.

" Wadi 'Aleyat flows north-west, and is nearly straight from end to end. The valley is broad, for a Sinai wadi, in proportion to its length, and slopes very rapidly, rising about two hundred feet in the first mile from its mouth and seven hundred in the third, after which it is lost amid the slopes of Serbal. There are a few shittim and tamarisk trees and bushes of retem towards the lower end, ban trees here and there grow singly in the ravines, and tufts of desert herbage struggle for life among the boulders. In the upper part of the wadi are two small palm-clusters, at an interval of about half a mile, overshadowing springs and pools of cool delicious water; it is just possible to reach these springs with lightly-laden camels by the barely perceptible track which thus far winds in and out among the chaos of the valley-bed. Serbal, rising grandly above the head of the wadi, is seen from the upper springs; but perhaps the very finest near view in the whole neighbourhood is to be had by ascending the adjacent hill side; a photograph we were so fortunate as to secure from the trigonometrical station on this hill gives an excellent representation of the majestic aspect of the eastern end of this splendid pile of granite, its grand serrated crest, and rugged sides riven and split into a thousand ravines and clefts. From the lower half of the wadi, only the eastern part of the mountain can be seen. Wadi 'Aleyat.

" Wadi 'Ajeleh is narrower and steeper than Wadi 'Aleyat, though about the same length, three miles, and similarly straight, it rises two thousand feet in all, one thousand in the last mile, terminating in a sharp knife-like ridge, 3,978 feet above the sea, with an immediate descent on the other side. The scenery is wild and gloomy; on the east, dark, savage glens pierce the congeries of rugged hills which Wadi 'Ajeleh.

occupy the whole central space in front of Serbal; on the west, the cliffs of Jebel Sull'a and Jebel Seraibil es Sugheireh tower to tremendous heights. But for a rude Arab footpath—the short cut towards Tor, from which the wadi derives its name of 'Ajeleh (haste, or quickness)—the valley would be almost impassable even to pedestrians, its whole bed being piled with huge boulders detached from the neighbouring heights, and torn and scoured in all directions by the ravages of winter torrents. The vegetation, though even scantier, is of the same class as that in Wadi 'Aleyat; the views of Serbâl are different, and confined to the western half of the mountain. Sinaitic inscriptions are abundant in both valleys, as well as in Wadi Nakhleh a tributary of Wadi 'Aleyat, and Wadi Th'mareh on the way to Jebel El Benat.

Gebel Serbal.

" The summit ridge of Jebel Serbal, about three miles long from end to end, has been frequently described as divided into five principal peaks. When looked at from the usual points of view in Wadi 'Aleyat, it certainly does to all appearance resolve itself into five or at most six massive domes, cones, or turrets. In reality, however, there are many more—ten or eleven certainly, besides several smaller ones, the number seen at any one time varying with the position of the spectator. From the low ground on the north side, the great peaks all appear to be nearly of the same height; the differences are, however, considerable; the loftiest one of all, El Madhawwa, 6,734 feet above the sea, is situated somewhat to the east of the central point of the ridge, but it lies so far back from the spectator on this (the north) side that its superior altitude is scarcely apparent from below.

Views of Serbal.

" There are several spots in Wadi Feiran which afford occasional partial glimpses of the summit of Serbal, hardly less striking than the nearer points of view in Wadi er Rimm and Wadi 'Aleyat. Near the palm-grove of El Hesweh is an effective standpoint, and there are others in the larger oasis above; they admit, it may be, of mere peeps up some little side gully, but of just those peeps which the artist loves to see, with some ridge or shoulder in the foreground to give distance and relief to the towering pile beyond. From the hill-tops north of Serbal the character of the views is exactly reversed, the whole of the noble range from end to end now standing clearly out against the sky, flanked by the scarcely inferior peaks of Jebel Shinenir on the east, Jebel Seraibil es Sugheireh and Jebel Sull'a on the west. No traveller should fail to ascend Jebel et Tahuneh and enjoy the prospect from its summit; and the adventurous mountaineer, willing to devote a hard but interesting day to the ascent of Jebel el Benat, will be well repaid, not only by a magnificent view of Serbal and an extensive mountain

landscape on every side, but by the sight of the stupendous gorge of Wadi Umfus on the eastern side of the peak, hardly surpassed in the combined grandeur of its rock scenery and beauty of its verdure by any defile in the country.

Ascent of Serbal.

" The summit basin of Jebel Serbal, from which the peaks spring, may be reached from Wadi 'Aleyat by one or the other of two so-called paths, the shorter and steeper one ascending by the precipitous rocky ravine called Abu Hamatah immediately beneath the principal peak, the other making a circuitous and gradual ascent by the Sikket Sadur and Sikket er Reshshah. These, as probably the easiest and shortest ways to the summit, are usually selected for travellers by the native guides, but there are doubtless others, known to ibex-hunters. The 'paths' are no more than goat-tracks, if so much. Burckhardt ascended by a narrow cleft behind the spring in Wadi er Rimm, and reached the basin in four hours, 'completely exhausted,' and the summit of the 'eastern' peak in three-quarters of an hour more. It takes from two and a half to three hours, actual going, to reach the highest peak from the upper palms in Wadi 'Aleyat, by the ordinary travellers' routes. The dangers of the ascent by these tracks have been somewhat highly coloured; it is hard and toilsome but scarcely perilous climbing, except when, as sometimes happens, the rocks in shade are coated with a thin film of ice. The principal peak is an enormous smooth dome of granite, so steep and bare in places that, if it were not for the excellent foothold afforded by the coarse surface of the rock, it would be almost impossible to get up and down, there being frequently nothing whatever to cling to. As it is, the difficulties are not great, and, in some of the steepest parts, steps of loose stones, skilfully laid—probably by the hands of hermits or pilgrims long ages ago—still remain to simplify the task. Burckhardt found similar steps on the peak which he climbed, and was told they were a continuation of a regular path ascending from the bottom of the mountain round its south and east sides, probably the identical path up Wadi Rimm el Mahasineh which we followed on a later occasion when on our way to Wadi Sigilliyeh. The extreme summit rock of the highest peak is a smooth cupola of granite, fifteen or twenty yards in diameter, from which a wedge-shaped shelf or promontory projects northward for about fifty yards, at a slightly lower level, to the extreme edge of a fearful precipice which plunges down four thousand feet into Wadi 'Aleyat. On this shelf are seen the ruins of El Madhawwa, 'the lighthouse,' a rude stone structure of which the origin and purpose are described by Mr. Palmer in Appendix I. Several Sinaitic inscriptions were noticed on the summit, and on the path by

which it is approached from the mountain basin. Close to El Madhawwa, in a cave or sheltered hollow formed by weathering, we found traces of inscriptions in whitewash or white paint, in the Sinaitic character, and there can be little doubt they were written by the men who built the beacon-tower, white marks from a similar composition being still visible upon some of the remaining stones, as well as fragments of mortar. Burckhardt describes with a good deal of minuteness his ascent of the *eastern* peak of Serbal, but it is not a little singular to notice how precisely his descriptions of the details seen on its summit tally with those observed by us on the principal peak further to the west the—steps regularly formed with large loose stones, about two feet high, forming a circle about twelve paces in diameter,' the 'inscriptions found on every granite block that presented a smooth surface,' the 'small caverns, large enough to shelter a few persons, with numerous inscriptions on their sides,' and so on. So precise indeed is the coincidence in many minute particulars that, notwithstanding the well-known accuracy of that eminent traveller, it is difficult to resist the inference that he must have been deceived (as, without actual measurements, the most experienced observer might well be in a single visit) by the bewildering character of the summit, and mistaken as to the point he reached. We did not visit Jebel Shinenir, the extreme eastern peak of the range; but there is no peak of Serbal proper, except the highest one, which answers to the above description.

View from Summit.

" The view from a Sinai mountain-top is always grand, and well worth the labour of ascent. Like scenery could hardly be met with elsewhere, so wild is it and yet so soft, so desolate and yet so beautiful. That bare rocks, with scarcely a blade of vegetation, could look so soft and beautiful, even in the pure transparent air and brilliant sunlight of the desert, would be thought incredible; it must be seen to be understood. From the summit of Serbal, the landscape on a clear day is one of the most striking and varied, if not the most extensive, in the country. Looking seaward, a wild chaos of rock and mountain fills the foreground; then comes the hot brown El Ga'ah; then Tor and its palm-groves, faintly seen, and the low coast range further north; then the glittering waters of the gulf, backed in the far distance by gray and purple ranges of African mountains. Looking inland, the eye roams over an amazing complication of desert mountains and valleys—a vast network, of which the white and gray wady-beds, winding in fanciful snaky patterns over the whole face of the country, are the threads, while mountains of all sizes, forms, and hues fill the interstices; northward, the far prospect is closed by the long blank line of the Tih escarpment; the peaks of

Katharina and Um Shomer rise darkly in the south-east; at your feet is Feiran, a thin green line of palms straggling through the hills.

"The ruins of Paran and its neighbourhood are described in Chapter VII; as also those on the summit of Gebel Sull'a (the noble cliff of smooth gray granite which overhangs the west side of Wadi 'Ajeleh), and the place of sacrifice on Jebel El Moneijah, whither the Bedawin are wont to resort 'to ask the favour of God Most High.' It only remains in connexion with this district, to give a brief description of the oasis of Wadi Feiran. Beginning at the mouth of Wadi 'Aleyat, this beautiful grove extends for about four miles up the valley; date-palm trees, of uncommon size and luxuriance as well as fruitfulness, form the bulk of the larger growth; there are also the tarfah or tamarisk (the manna-bearing tree of the Peninsula) in considerable numbers, the acacia seyal (shittah), armed with fearful spikes, and the sidr which yields a small acrid fruit called nebk; the undergrowth consists of rushes and other marsh plants; and a variety of herbs and grasses, turf, moss, and small flowers carpet the soil in the moister spots. A dry torrent-bed, alternating from side to side, winds through the grove and marks the course and ravages of recent floods. Clusters of rude Bedawin houses, built of loose stones and roofed with palm-boughs, here and there skirt the trees; and sometimes you come upon irregular walled enclosures, containing native gardens of maize and tobacco, which are irrigated with water raised from adjacent wells by means of the simple mechanical contrivance termed a *shuduf*. Bedawin tents may usually be seen peeping out here and there from among the trees; and there are neatly kept native burial-grounds at three or four points in the oasis, one of them containing the tomb of the great Sheikh Abu Shebib, patron saint of the district and a terror to all false swearers. A little stream ripples through the grove, first bursting to light at a point between two and three miles above Wadi 'Aleyat, and now and then disappearing for a short distance as it descends the valley; at El Maharrad it sinks into the gravel, and is never seen again; (the lower grove, at El Hesweh, now contains no running water). The stream is now said to be perennial, though prior to the great seil of 1867, which scoured away many feet of surface soil, there does not appear to have been a never-failing flow. The pass of Feiran is narrow, sometimes but one hundred and fifty yards across, and its rock scenery bold and picturesque; the number of dykes is wonderful, and the rugged cliffs rising six or eight hundred feet on either hand—gneiss and mica-schist, greenstone and granite—display a brilliancy and variety of colour unequalled up to this point

Oasis of Ferân.

of the march: their nakedness serves moreover to enhance the fresh living beauty of the oasis they enclose. It would be difficult to overstate the pleasure with which after days, or it may be weeks, of the usual desert scenery, the traveller greets this charming defile; one must have marched day after day in the wilderness, over endless tracts of sand, rock, or gravel, sparsely dotted with parched and sickly herbage, to understand the real luxury of a verdant spot like this—its rich foliage and its shade, its running water and moist vegetable soil, its graceful palms and feathery tamarisks, bulbuls and other songsters singing in the grove, blue sky above, and brightly coloured rocks seen through the trees."

When visited in January 1899, shortly after a day and night's heavy rain, this oasis was flooded, being almost impassable for loaded camels. After passing the gardens and palmgroves the heggin had to wade knee-deep in water through narrow channels amongst reeds and bulrushes which in many places reached up to one's face in the saddle. From the lower end of the oasis a strong stream of water was issuing which continued down to El Heswa in a properly kept channel. It thus seems that the water-supply was better than it was when the Survey Officers visited it in 1869.

Tarfa grove.

Leaving the oasis and the palms, the road immediately entered a large grove of tarfa trees, which by their thick trunks and general luxuriance give evidence of the depth and richness of the soil. On either side of the wadi stand mounds of alluvial deposits as much as 30 metres in thickness, sometimes only in isolated blocks near the mouth of tributaries, or again perched high up on the side of the cliff showing vertical faces, and weathering in a fantastic manner. These extend to the lower end of the oasis of Ferân but are never seen afterwards. There they have been evidently used as burial places in early times, as there are numerous caves and openings in them.

This tarfa grove continues for two kilometres until near the mouth of Wadi el Akhdar where it dies out. After passing this wadi, the valley undergoes a sudden constriction, due to a neck of quartz-felsite through which the drainage has to pass by a very narrow opening

El Buwêb.

known as El Buwêb, the gate of Ferân. Above this the wadi is called Solâf, where, according to the account of the Ordnance Survey Officers, a grove of tamarisks extending for about four kilometres was swept away by a *sêl* or torrent. The small grove of about 1 kilometre in length must therefore have grown up since then. About a kilometre higher up from this point the Wadi el Sheikh enters from the north-east.

It is now proposed to describe separately the three great valleys—Wadi el Akhdar, Wadi el Sheikh and Wadi Solâf—which find their way to the sea through the gorge of Ferân, beginning with the most northerly—Wadi el Akhdar.

Wadi el Akhdar.—This wadi enters Ferân through an opening about 50 metres wide in a ridge of gneiss 250 to 300 metres high containing many dykes. Passing up it over a rough floor of boulders, the gneiss is passed through after a kilometre has been traversed, and immediately after the wadi passes close along the foot of a high, red granite boss, Gebel Yena, on the north, which towers above it in a precipitous front 600 to 700 metres high. It is this boss which forms the plateau of which Gebel Goze and El Banât are the outstanding headlands to the west, and stretching away towards the basin of Rahaba, ends in a precipitous cliff to the north-east, shading off more or less into the gneissose granite in the neighbourhood of El Banât. The surface of this plateau is much streaked with black veins of an acid rock which give it a stripy appearance.

On the south side the wadi is bounded by low hills of gray granite much cut up by red felsitic dykes running in a north-easterly direction. After leaving the gneiss the wadi makes a sharp bend round a headland of the red granite above-mentioned, and after a straight reach of a little over a kilometre, makes a curious U-shaped bend into this plateau, where it receives the two feeders of Wadi Yena, in both of which water is found, the western one being also called Wadi Main. Here the wadi is 200 to 300 metres wide and contains several terraces of sand and boulders. There can be no doubt that the erratic course of the wadi is due to the different hardness of the two rocks composing its sides, and that its course has been determined by the more rapid weathering of the softer rock, thus producing a waterway along the junction line. The same thing is seen in Wadi el Ghadîr or Satakh, and Wadi Retema, in both cases formed along junction lines.

Wadi Satakh.—This wadi is very wide and open at its mouth, many terraces and mounds of sand occurring in it, and it is very much frequented by the Bedawin who bring their flocks to graze on the plants which grow here and on the plateau. Higher up there is a good supply of water. Ibex abound here, a flock of ten being seen on the hills in the early morning.

Wadi Retema.—About 3·5 kilometres from the mouth of the last valley is the entrance of Wadi Retema, which here, together with the wadis Barra, Esh, and El Akhdar, forms the small, open plain dotted with retem called Erwês el Ebêriq (the top of the ground with white patches).

Wadi Retema is a small straight valley which comes down from the mass of red granite between Wadi Barra and Gebel Yena.

Wadi Barra.—This wadi takes its origin near the curious conical peak, Zibb el Bahêr Abu Baharia, and flowing south-east slowly becomes enclosed between red granite hills higher on the west than on the east, and gradually narrows and deepens as it descends. About 2·5 kilometres further down, Wadi Erthama enters from the north-east, a small valley in which there is said to be a spring of good water.

A little over two kilometres lower down, Wadi Retema comes in on the same side, and half a kilometre further down the wadi passes out between the two granite bosses—Gebel Retema and Hamra—which form the gate-posts of the valley in a way which gives the name to the valley (the wadi of the passers out). From this to the Erwês el Ebêriq, the valley runs through low hills for about 1·5 kilometres. Throughout its whole length of 8 kilometres or so, the bed of the wadi is excellent going, being made up of compacted granite sand and clay, in which a few retem bushes and many crocuses were growing. Its fall is more rapid than in most other valleys. Down this wadi comes the direct road from Suez to the Dêr at Gebel Musa.

Wadi el Esh.—The next valley, Wadi el Esh, is a wide, sandy water-course in which is a considerable Bedawin encampment; in it the head sheikh of the Towara tribe, Abu Nasir, has his home. Retem trees abound, and there is plenty of food for the flocks in the district around. As this wadi nears Gebel Hamra it narrows considerably, and skirting its edge, makes its way rapidly up to the top of the plateau of pink granite where it heads near the source of Wadi Bum, the upper part of Monia, a tributary of Wadi Siq.

Wadi Solêf.—Opposite Erwês el Ebêriq, enters the Wadi Solêf (the borrowing wadi) so called because several roads meet here and the Bedawin have the opportunity of borrowing from each other. Up this the Gebel Musa road runs, and drops down into Wadi el Sheikh on the other side of the low ridge separating the latter from Wadi el Akhdar.

From the top of the ridge separating these two wadis, an excellent view of the main mountain system of the peninsula can be obtained. To the west the range of Serbâl rises grandly out of the surrounding country with the rounded conical peak of Bêdhat Um Takha forming its eastern outpost; while away to the south are the dark rounded hill of Madsûs, and the double-peaked crest of Gebel Mareia or Tarbush, as it is named on the Ordnance Survey map; and stretching away further to the north is the massif of Gebel Musa and the hills round

about it, of which Gebel el Gharbi and Watia are the most easily recognized.

From this point onward up this valley, no well-marked drainage comes in until Wadi Harqus is received from the east. This is a fairly long wadi, which taking origin in the wide and undulating Fersh el Elwi el Agramia, and winding in and out among gneissose hill, ridges eventually discharges itself after a course of 10 kilometres into Wadi el Akhdar. There is a well-marked camel track up this valley leading on to the plateau above-mentioned, and thence either into Wadi el Sheikh, or across the fersh of Elwi el Agramia to El Watia. Wadi el Akhdar. Wadi Harqûs.

After leaving the mouth of Harqûs, Wadi el Akhdar makes a fairly straight north-east course through low ridges of gneissose granite for about 10 kilometres when it receives Wadi Hamanier, a tributary which drains the plateau in the vicinity of Naqb Shêqer, but heading in reality at the foot of Gebel Dhalâl. This evidently bears two names as it was named by our guides Wadi Maiat. From this point the wadi turns due east, and after winding about among low hills for about 6 kilometres, reaches En el Akhdar. From this valley the northern route to Gebel Musa crosses El Akhdar straight for the fersh of Elwi el Agramia. Wadi Hamanier.

En el Akhdar.—This is situated at the foot of the vertical cliff of a boss of porphyritic quartz-felsite, at an altitude of 1,150 metres above the sea. Here there are three wells about 4 or 5 metres deep in all of which is water. There must have been a small village here at one time for there are ruins of several houses and gardens, the walls of which are still standing, and there are the remains of a shaduf for lifting the water from the wells for irrigating the gardens. Looking up the wadi it presents quite the appearance of an oasis, the various palm and sidr trees making a good show of verdure. These wells are much frequented by the Bedawin, being the principal water supply of the vicinity.

A little distance beyond the wells where the wadi bends sharply to the north, there is a fairly large burial ground. In the sandy soil in the bed of the wadi grow numerous lilies, some a delicate purple, while others are pure white, and a few crocuses also occur with them. From this point to its origin in the south-east of Dhalâl the valley is practically on the Fersh el Elwi el Agrami.

This wadi for the whole of its course is fairly shallow-sided and broad, (about 200 or 300 metres) in its lower reaches, and well clothed in vegetation, retem being fairly common in its upper part. Numerous

Bedawin live in the side wadis and possess large flocks of goats, several donkeys and camels, which obtain a plentiful supply of food from the different kinds of plants which grow in the valley and on the plateau.

Wadi el Sheikh.

Returning to the mouth of the second great waterway which falls into Ferân, the Wadi el Sheikh, so called because of the tomb of Sheikh el Nebi Sala which is situated near its head, enters about 2 kilometres south of El Akhdar, through an opening in the steeply-tilted gneiss ridge about 200 metres high which extends across the country for tens of kilometres. Here the wadi is about 200 metres wide; as it is ascended it narrows considerably at the same time winding about sharply. Further up, about 2 or 3 kilometres from its mouth, it again widens into a broad valley between low hills of gray granite, which are drained by short, steep wadis on either side. Here also occur some fine examples of terraces which continue for about 5 kilometres up the valley. Seyal trees are found in the lower reaches; but higher up retem bushes occupy the wadi entirely, until near its entrance into the hills round Gebel Musa.

About one kilometre higher up, Wadi Solêf enters from the north, the central road from Suez to El Dêr lying in it. On entering El Sheikh the road splits into two, the path up Wadi Sahab towards Naqb Hawa being only available for lightly laden camels, while that for heavily laden animals follows the main wadi.

Wadi Sahab (Valley of spreading or flowing water).

This is a wide straight wadi which rises rapidly in a south-easterly direction among the low hills which occupy the country between Solâf and El Sheikh. It is between 7 and 8 kilometres long; in the upper third of its course it is practically a plain over 1 kilometre in breadth; and at its head is nearly 300 metres higher than its mouth.

Following up Wadi el Sheikh, which is here a wide open valley clothed with retem, rimth, etc., Wadi Magheirat is reached after a walk of 10 kilometres, a short, wide valley coming from the north-east, at the mouth of which some Sinaitic inscriptions were seen on the right bank. From this point, El Sheikh, which previously had been going north of east, now bends round to east-south-east, at the same time narrowing, and the hills on each side although still low, slope back to loftier peaks about 3 kilometres to the south. On the north, the plateau of Fersh el Elwi el Agramia is not over 100 metres above valley level. About

Wadi Hamâta.

11 kilometres above Magheirat the mouth of Wadi Hamâta (the valley of wild figs) is reached, which is about the first important tributary met with since leaving Wadi Sahab. In this valley some wild fig trees still grow; water is found in it; its bed is very rough and makes walking very difficult; and small water-falls and sheer precipices block the way, necessitating the climbing of the hills on either side in order to

go on. Several families of Bedawin live in this neighbourhood, their flocks picking up their food on the hills and in the small wadis.

Near by is the mouth of Wadi Qassab, (the valley of the reed) down which a path comes over a piece of difficult ground from the head of Solêf.

Close by is a Bedawin cemetery, and above this begins the Tarfat el Gidarên, a tarfa grove of over 2 kilometres in length. The trees are the largest yet seen in any part of the peninsula. **Tarfat el Gidarên.**

At the same place the finest examples of terraces, and at the same time the most extensive, begin here and continue up to the entrance of El Watia. They extend some distance on either side of the wadi, and especially on the Elwi el Agramia side.

About one kilometre or so above the tarfa grove, the wadi opens out until it is nearly 300 metres wide, then bending sharply to the south it suddenly narrows into the pass of El Watia.

This is the only means of entrance for heavily-loaded camels into the central mountain area. It is a breach in the precipitous granite ridge of El Gharbi, and is an extremely fine gorge. On either side the granite rises up in sheer precipices, breaking into rugged peaks towering on the eastern side 450 and on the western 600 metres above the valley. It varies from 30 metres in width at the northern entrance to about 100 where it opens out into the plain behind, and is about half a kilometre long, having a firm gravelly floor, and a very tortuous course. On the east side there is a peak somewhat resembling an armchair in shape which the Bedawin call Maqad el Nebi Musa (the seat of the Prophet Moses). **El Watia.**

Inside the pass the wadi opens out, and the country to the east is a succession of parallel ridges and valleys, which higher up is replaced by hills. The valley here is wide and good going. About 6 kilometres from the pass of El Watia, is the tomb of Sheikh el Nebi Sala, near by which is a large burial ground. Near this point the road to Aqaba leaves the valley on the east. Five or six kilometres further on the wadi divides into two, the Wadi el Sudud and Wadi el Dêr bounding respectively the eastern and northern sides of Gebel el Dêr. The road to Ras Safsâfa (the willow peak) now about 5 kilometres up the last mentioned valley, runs in a south-westerly direction.

The following is a description taken from the Ordnance Survey of Sinai, Part I, of Jebel Musa and neighbourhood:—

"The physical features of Jebel Musa and the country in its neighbourhood are so clearly represented by the photographs, models, sections, and six-inch plans that the task of describing them becomes short and easy. **Gebel Musa and neighbourhood.**

"The mountain mass of Jebel Musa is nearly a mile broad and rather more than two miles long, and the direction of its longer axis is nearly north-west; on the north-east it is separated from Jebel ed Deir by a deep, narrow glen named Wadi ed Deir, the 'Convent valley' —sometimes also called Wadi es Sho'eib, 'the valley of Jethro'—in which stands the Convent of St. Katharine; on the south-west, Wadi Sh'reich, a still narrower ravine, divides it from the long subordinate ridge of Jebel Fera', which again is cut off by Wadi el Leja from the huge red bluffs of Jebel el Hamr.

"These three mountain masses are composed mainly of red or pink syenitic granite. The profile of greatest elevation descends to the north-west. Jebel el Hamr forms the northern shoulder or buttress of the lofty mountain platform on which Jebel Katharina rests, and is the highest of the three, its loftiest portion having an altitude of 7,519 feet, while the summit peak of Jebel Musa is 7,363, and that of Jebel ed Deir (Jebel 'Aribeh) but 6,739 feet above the sea.

"A conical mountain, Jebel Moneijah (5,987 feet), stands at the head of Wady ed Deir, and is connected by low ridges with Jebel Musa on one hand, and Jebel ed Deir on the other. These two ridges separate the basins of Wady Seba'iyeh and Wady ed Deir from one another, while a third, which joins the south end of Jebel Musa with the neighbouring mountain Jebel Abu'aldi, divides the basins of Wady Seba'iyeh and Wady el Leja. In all other respects Jebel Musa stands alone.

"Wady el Leja, after a north-west course of about two miles, sweeps sharply round the end of Jebel Fera', and under the successive names Seil Leja and Wady ed Deir, passes north-east for three miles along the base of Jebel Musa (Ras Sufsafeh) and Jebel ed Deir to Wady es Sheikh, here uniting with Wady es Sudud from the south; it receives on its course Wady Sh'reich and Wady ed Deir (Sho'eib) from the south-east, and the broad wady or sloping plain of Er Rahah from the north-west. Thus the drainage of the whole special survey area, excepting only a narrow strip along the west and north-west edges, passes out near its north-east angle by Wady es Sheikh. Wady es Sudud skirts the eastern and third side of the triangular block of Jebel ed Deir. Two miles above its mouth it takes the name of Wady Seba'iyeh, and continues for about three miles further south to its source in the slopes of Jebel Hadaiyid.

El Fur'eiah.

"Jebel Musa and Jebel ed Deir are confronted on the north by a portion of that great ring or cluster of granitic peaks, known by the general name of El Fur'eiah, which encloses the fertile basin of

Deyset Fur'eiah, and forms the northern outpost of the mountain nucleus of the Peninsula. Jebel 'Ajramiyeh (6,296 feet) and Jebel Khizamiyeh (6018 feet) are the dominant peaks in the south of this cluster.

"The summit of Jebel Musa presents the form of a long, narrow trough or basin, enclosed at its sides by a series of comparatively low peaks and ridges, but at its two ends by tremendous piles of mountain, that on the south-east rising into a single-pointed peak 7,363 feet above the sea, while that on the north-west is divided into three or four massive bluffs. The peak at the south-east bears specifically the name of Jebel Musa, 'the mountain of Moses,' and is regarded by the monks as the Mount of the Law, the true Sinai of Scripture; by the Bedawin, who have no tradition of the Proclamation of the Law, simply as the mountain where God spoke with Moses. Its upper portion is of gray granite, weathered externally to a very dark green, and contrasting well with the red granite which lies beneath. On its south side there is a tremendous sheer descent of nearly 1,100 feet to the ridge which crosses to Jebel Abu'aldi, and a further and more gradual fall of 1,100 feet to the bed of Wady Seba'iyeh; its northern slope descends at a steep angle to the mountain basin 850 feet below. Side by side on its summit stand a mosque, now well nigh in ruins, and a Greek chapel, both built of hewn red granite blocks, the materials of a former chapel said to have been destroyed by the Bedawin; close by there is a small hollow in the solid rock, doubtless produced by weathering, into which, according to the simple Arab tradition, Moses shrank, when the Most High God spoke to him, saying, 'Creep thou into the rock, O Moses, for thou can'st not bear my glory.' The range of high bluffs at the opposite north-western extremity of the mountain basin bears the name of Ras Sufsafeh, from a small willow or osier which grows among the rocks, on its south side. From its southern and highest point the profile of the peaks or bluffs descends about four hundred feet to its extreme northern end. All round its north-western face this range falls abruptly to Wady Sh'reich and the Seil Leja, and forms, together with the high bluffs of Jebel Abu T'reif and Jebel Arremziyeh which overhang the Convent valley, a magnificent cliff front some 2,000 feet high, which, as looked at from the north-west, is perhaps the grandest natural feature in the whole Peninsula.

Summit of Gebel Musa.

Gebel Musa Peak.

Ras Sufsafeh.

"*Er Rahah.*—The plain of Er Rahah is about a mile and a quarter in length from its crest to its lowest point near the foot of the Ras Sufsafeh, and half a mile in average breadth, thus containing an area of some four hundred acres exactly facing the mount. Its general inclination

Er Rahah.

is south-east-by-east 2 ¼°, or 1 in 26. The surface is of granite gravel, for the most part smooth and even, and plentifully covered with herbs, chiefly '*abeithiran*' and '*shiah.*' Beyond its crest the plain soon narrows, but there is still, for about a mile, a considerable open space (the head of Wady Abu Seileh) of the same character as Er Rahah, and sloping so gradually to the north-west that the cliffs of Ras Sufsafeh are not lost to view. From its lower end, near the foot of these cliffs, the plain merges into the Seil Leja on the west and Wady ed Deir on the east, the one, though more stony and rough than Er Rahah, affording an extensive open space, the other nearly as smooth and even as the plain itself. Ras Sufsafeh is well seen from the Seil Leja, and also from Wadi ed Deir right down to its mouth, these side views, however, do not equal the prospect from the front.

Space for encampment.

"In order to estimate the extent of open camping ground which faces the Ras Sufsafeh from different quarters, we may add to the 400 acres of Er Rahah proper, 163 for the upper part of Wady Abu Seileh, 227 for the area more or less level in the Seil Leja, and 260 for the bed of Wady ed Deir, making in all 1,050 acres. To this again may be added about 150 acres of space available for rough encampment on the lower slopes of the hills. So that we have altogether an estimated area of 1,200 acres (nearly six million square yards) in the plains and wadies and their borders, from all points of which the Ras Sufsafeh is not only distinctly seen, but is also the most prominent feature in the landscape; and tents situated in any part of this space might well be said to have been pitched "before" the mountain in question.

Space for Spectators.

"As a site from which to witness any spectacle on the top of the Ras Sufsafeh, the plain and hill slopes which face it would accommodate almost any number of spectators. A million persons, at the ample allowance of a square yard each, would occupy about 207 acres, that is, scarcely more than half of the area of Er Rahah at once, and so be able to advance or retire along it at will. Two millions at the same rate would cover the plain from its crest to the nether end of the mountain, but still be able to fall back along the Wadi Abu Seileh without losing sight of Ras Sufsafeh; while in either case large additional numbers might find standing room on the lower slopes of the hills.

View from plain.

"The prospect from the plain of Er Rahah is so impressive and sublime that no beholder can fail to be attracted by it. Its beauties moreover gain upon you rather than diminish the more you become familiar with it, and the more it is contrasted with other mountain views; such at least was our experience from a stay of many months in the country, and an acquaintance with every class of its scenery. It

is indeed unrivalled; there is nothing else like it in this or any other part of the Peninsula; the long, wide plain sloping down to the mount, the noble amphitheatre of hills all round, and the bold precipices of Ras Sufsafeh, the 'brow' of Gebel Musa, overlooking and seen from every point in the plain below, the more imposing as it is by far the most conspicuous feature in a landscape where all is grand. The Ras Sufsafeh has a majesty peculiarly its own—a look of stately, I might almost say awful, grandeur, which has stamped it on our minds as by far the most remarkable mountain front in the Sinai Desert. In gazing on that noble cliff and spacious plain at its base, its needs no effort or enthusiasm to recognise their peculiar fitness for the events described in Scripture as having attended the Promulgation of the Law.

Isolation of Ras Sufsafeh.

"Isolation of Ras Sufsafeh.—There is little or no broken ground at the base of Ras Sufsafeh, where it confronts Er Rahah. Its cliffs, which start suddenly and steeply from the Wady Sh'reich and Seil Leja, become impassable about half way up, and the highest points can only be reached from the mountain basin in their rear. On the north-east they rise almost as boldly from Wady ed Deir, though here they are less inaccessible. On the north-west, the otherwise complete isolation of this magnificent front is slightly broken by the big steep Wady Sh'reich, which, together with the low ridge of Jebel Fera, interrupts the sheer descent on this side into Wadi el Leja, and to some extent mars an effect which, but for this break, would be absolutely perfect. Hence, the view from the head of Er Rahah, at which part Jebel Fera is almost hidden by nearer mountains, is perhaps more effective than that from points lower down in the plain.

Gebel Musa.

"Summit peak of Jebel Musa.—The summit peak of Jebel Musa lies so far back that the Ras Sufsafeh, though more than 400 feet lower, altogether conceals it from a spectator on the plain; indeed, it cannot be seen at all from low ground in the neighbourhood, except from points far up in the side valleys, or others still further south. Wady Seba'iyeh, in its rear, commands perhaps the best of all these views; but the tract of low hills bordering on this valley—that which occupies the space between Jebel Moneijah and Jebel Abu Aldi, and which appears so level when looked down upon from the summit of Jebel Musa that many travellers have been betrayed into describing it as a plain—proves, when examined, to be a sea of rock-strewn hillocks and ravines; and a single glance at the plan or model is sufficient evidence of the groundless nature of any statements to the contrary.

View from Wadi Seba'iyeh.

Springs and streams in the district.

"Water and verdure etc., of the district.—Perennial springs and rivulets of excellent water are abundant on the slopes of Jebel Musa,

and in the neighbouring hills and valleys. Indeed this district has perhaps a more plentiful water-supply than any other in the Peninsula. The Convent of St. Katharine has two copious springs, and there are five or six others in the cliffs above Wady ed Deir, besides small streams n Wady Sh'reich and Wady el Leja, and several springs and wells in the Seil Leja. The streams in Wadies et T'lah, Zawatin and Abu Seileh have been already mentioned; the Deyset Fureiah has a goodly water supply; Mr. Holland found a small brook in a ravine on the east of Wady es Sudud, and there is a spring on Jebel ed Deir opposite the mouth of Wady Um Girsum. These form the principal supply in the immediate neighbourhood of Jebel Musa, and there are others, too numerous to mention, in the surrounding hills and valleys. Pasturage also is fairly abundant in this district; the Deyset Fur'eiah, one of the largest and most fertile mountain basins in the country, is fruitful with desert herbs and grasses, and much resorted to by the Bedawin; and there is a goodly sprinkling of fragrant herbage, affording nutritive feed for camels and goats on many of the mountain sides, notably on the upper slopes of Jebel Katharina, which at some points have almost the appearance of well-clothed downs.

Pasturage.

Monastic Ruins.

"Monastic buldings, most of them in ruins, are very numerous in the valleys immediately surrounding Jebel Musa and on the sacred summit itself; cells and chapels, nestling amongst the cliffs and rocks, meet the eye at almost every turn, and Wady el Leja contains the ruins of two branch convents.

Gardens.

"Gardens, still beautiful and fruitful though sadly neglected, surround some of the larger ruins; the gardens of the deserted convent of El Arba'in, in Wady el Leja, is about 15 acres in extent, or more than twice as large as that of St. Katharine's, and there are several others of a goodly size in the valleys west of Ras Sufsafeh. The monks, though still claiming the rights of proprietorship over these old gardens, and extorting a small annual percentage of produce from the Arabs who rudely tend them, unfortunately take no steps to ensure their proper cultivation.

"It is not only in the immediate vicinity of Jebel Musa that the monastic remains are to be seen. Nearly every available spot in the hills and valleys for miles round seems to have been taken advantage of; wherever water and the smallest scrap of open ground are found, you are almost sure to come upon these ruins and the vestiges of former cultivation. I have already mentioned the rich fruit groves of Wady et T'lah, the most fertile by far of all the valleys in the central cluster; numerous gardens and ruins dot the Deyset Fur'eiah and the

hills around it; and in Wady Gharbeh, just below the point where it breaks from the mountains, there is quite an imposing cluster of similar remains, with numbers of date-palms and a stream of cool delicious water.

" *Wadies.*—The wadies which surrounded Jebel Musa on the east, west, and south are extremely wild and rocky. Wady el Leja is filled with enormous fragments and boulders of granite; Wady Sh'reich is even worse towards its mouth; from the chapel of St. Pantaleemon there is a steep rise of six hundred feet in half a mile over tremendous piles of rocky debris from the cliffs of Ras Sufsafeh; but higher up, the valley is more smooth and level. In Wady ed Deir, as far at least as the Convent, there are fewer boulders and better walking, the path lying in many places over the bare solid rock which forms the wady-bed. There are several Sinaitic inscriptions in Wadies el Leja and ed Deir. Wadies.

" Paths up Jebel Musa.—The summit basin of Jebel Musa may be reached by either of five paths or tracks, as follows:—

" (1) The sikket Syedna Musa, or "Path of our Lord Moses."—This route, leaving the Convent in a southerly direction, climbs the mountain side by a steep ravine, and reaches the basin at Elijah's Chapel, close to the foot of the peak of Jebel Musa, after an ascent of about 1,500 feet. It is the track, which has been followed by monks and pilgrims for many centuries, past a rude flight of rocky steps, formed of huge slabs of granite arranged with considerable skill, but now destroyed at many points by the fall of rocks or rush of torrents. Its course lies amid the wildest and grandest natural features, tremendous masses of fallen granite, towering precipices, and mighty peaks and pinnacles of rock. Several objects of legendary interest are passed on the way; the Ma'yan Musa or 'Spring of Moses' rises to the surface in a cool shady rock grotto about four hundred feet up the mountain side; it is said by the Bedawin to be the identical well at which Moses watered Jethro's flocks; the monks tell you it was miraculously created for the benefit of St. Stephanos, a former cobbler hermit who lived here. Five or six hundred feet higher up is the chapel of the Virgin of the Economos, built in commemoration of the supposed miraculous extirpation of fleas in the Convent, which forms the subject of a well-known legend. Between this chapel and the summit there are two fine arches; then the mountain basin is reached. Paths up Gebel Musa.

" (2) The sikket el Basha, or "Pasha's road".—This road was begun by Abbas Pasha who did not live to see it finished; though in places out of repair, it is for the most part in fair condition and still passable for camels. Ascending Wady ed Deir to its source in the

ridge which connects Jebel Musa with Jebel Moneijah, it winds in long steep zig-zags up the south-east face of Jebel Musa, and ends abruptly just at the edge of the basin, at a point a little above Elijah's Chapel.

"(3) The sikket Sho'eib, or "Path of Jethro".—A very precipitous rocky ravine, containing only the faintest traces of a path, which ascends from near the ruined barracks in Wady ed Deir, and reaches the basin at the back of Ras Sufsafeh after a climb of about 1,500 feet.

"(4) A rude winding track which ascends the western cliffs of Jebel Musa to the mountain basin from a point about two-thirds of the way up Wady Sh'reich, and, according to an early tradition, is the path formerly used by Moses.

"(5) A winding path, less rocky and precipitous than the Sikket Syedna Musa, which rises from the convent of El Arbain in Wady el Leja to the south-west corner of the mountain basin. It was probably constructed for the use of pilgrims, and is constantly followed by them in descending from Jebel Musa on their way, in the usual circuit, to the Deir el Arbain and Jebel Katharina.

View from Summit.

"From Elijah's Chapel, a further flight of steps, like those on the Sikket Syedna Musa, leads on to the summit peak of Jebel Musa, passing a little way short of the highest point the mysterious "camel's footprint" in the solid rock. The prospect from the summit is magnificent, being limited on the west and south-west only by the mountain masses of Jebel Katharina, Jebel el Hamr, etc. It is quite incorrect to say, as has been often declared by travellers, that the Gulf of Suez can be seen from this point.

"To reach the highest peak of Ras Sufsafeh from the chapel of Elijah, there is a rough scramble for a mile or more along the mountain basin to the back of the bluff, over a rugged path, now ascending, now descending, and passing in and out between enormous domes of granite; then a breathless climb of three or four hundred feet up a steep, rocky ravine which divides the two westernmost bluffs, till at last, on reaching its crest, situated in a deep narrow cleft between tremendous walls of rock, you come suddenly into view of the plain of Er Rahah.

View from Ras Sufsafeh.

But, fine as is this prospect, a still finer one awaits the traveller who ascends the rugged cliff on his left hand to its topmost point, the highest in the whole range of bluffs. It is a noble panorama, and has often been described by able pens. In front, the long gray plain of Er Rahah sloping down from its crest more than two miles away to its base 2,000 feet beneath your stand-point, and enclosed between long ranges of stately hills, which extend far back along the line of

the Nagb Hawa; below, the curious curved mound, Ujrat el Mehd, forming a kind of natural amphitheatre which exactly faces the mount; behind, the rugged basin of Jebel Musa ending in the traditional peak crowned by the memorials of its double sanctity; and around, on all sides, a stormy sea of mountains of indescribable grandeur. No one can gaze unmoved on such a landscape; and its natural wonders are heightened in their effect on the beholder's mind as he thinks upon the great scenes of the Proclamation of the Law, once enacted, probably, upon this very spot.

"The Cluster of Jebel Katharina.—South-west of Jebel Musa, three conical peaks rise from the north-western ridge of that great mountain mass of syenitic granite which forms at once the kernel and the culminating feature of the Sinai Peninsula. Jebel Zebir—which is interpreted to mean "The mountain on which God spake to Moses"—8,551 feet above the sea, is the central and highest of the three. Jebel Katharina, so called from the monastic legend that St. Katharine's body was brought hither from Alexandria by angels, comes next in altitude, being but 25 feet lower; it lies half a mile to the north of Jebel Zebir. The third and lowest, Jebel Abu Rumail, is a mile south of Jebel Zebir, and has an altitude of 8,427 feet. Further south, the mountain mass expands into an undulating fersh, or upland plateau, the entire summit area being about twelve square miles, and here and there rising into dark, shattered peaks which overhang the surrounding valleys. The most remarkable of these is Jebel Koli, a sharp pinnacle or cusp at the southern end 3,236 feet above the sea. The exposed cliffs and peaks are dark, almost black in colour, thus imparting a sombre character to the scenery. Jebel Um Iswed, "The Mountain of Blackness", on the south-west, owes its name to this peculiarity.

Gebel Katharina.

Gebel Koli.

"Jebel Um Shomer (8,449 feet) had, prior to our survey, been supposed by many to be the highest, and Jebel Katharina the next highest, peak in the country. The latter mountain, however, has the superiority by about 77 feet, and Jebel Zebir, which no one seems to have thought of, outstrips them both.

Gebel Um Shomer.

"Ascent of Jebel Katharina.—The path from St. Katharine's leads up Wady el Leja as far as the Convent of El Arba'in. On his way round the foot of Ras Sufsafeh, the traveller passes several objects connected by absurd monkish legends with events described in Scripture, and grouped, without regard to facts or probability, within a pleasant walk of the Convent gates; such for instance, are the Mould of the Calf, the Burial-place of the Tables of the Law, and the Cave of Korah, Dathan and Abiram: also in Wady el Leja, about

Ascent of Gebel Katharina.

half way up, the so-called "Stone of Moses" (Exodus xvii., 6), one of scores of rocks of a similar size, and kind scattered up and down the wady. At the Deir el Arba'in, he turns south-west along the Shagg Musa, a dark, rocky glen which runs far up into the north-eastern slopes of Jebel Katharina. A mile or so further on, the path leaves the bed of the ravine and henceforward to the foot of the last rocky ascent of the summit cone, it is a tiring heavy climb up an abrupt and crumbling mountain side; when covered, as in winter they sometimes are, with snow, these slopes are extremely difficult of ascent. A beautiful spring, Ma'yan es Shinnar, the "Partridge fountain" is passed on the way. The summit peak is a huge naked block of syenitic granite, descending somewhat steeply on all sides, but so broken into clefts and ledges that there is no danger or difficulty in climbing it. A little chapel, of the usual kind, dedicated to St. Katharine, crowns the topmost block.

Ma'yan es Shinnar.

View from Summit.

"As its peak is all but the loftiest, so is the view from Jebel Katharina one of the finest in the country. From this high and freezing standpoint you may, on any clear day, look down upon three-fourths of the Peninsula of Sinai, from Jebel Hammam Far'un on the north-west to the mountains of Wady el Ain on the north-east; from Jebel Musa and Ras Sufsafeh, which seem quite close to your side, and the labyrinth of monster mountains spread out like a model at your feet, to the glimmering waters of the twin gulfs and the hills of Arabia and Africa beyond them on either hand. Jebel Zebir and Um Shomer slightly spoil the view southward, and little can be seen beyond the Tih escarpment on the north; but in all other quarters the prospect is most extensive. Ras Muhammed is not to be seen, though you can trace the two arms of the Red Sea almost to their point of junction.

"The whole prospect is magnificent, grander even than that from Serbal; the effects of colour, light, and shade excite the admiration of every traveller; the colours on land, sky, and sea are simply enchanting, and the intense stillness and silence of the desert lends mystery and solemnity to the scene. But it is at sunrise or sunset that a Sinai mountain landscape is seen to its greatest perfection. Perhaps the hour of sunset is to be preferred to any other. Then you have orange, pink, green and blue in the sky, indigo, lilac and rich red brown like burnished copper on the hills, colours ever changing and deepening, shadows ever lengthening, as the sun slowly declines."

Country between El Sheikh and Solaf.

Returning down Wadi el Sheikh to the mouth of Wadi Qassab, the path connecting this wadi with Solâf on the left is taken. On the

watershed from the top of any of the rounded peaks a good view of the country enclosed by these two valleys is obtained. On the south it is bounded by the red granite range of El Gharbi which rises abruptly from the terrace-covered plain. From the foot of this ridge the ground slopes up to a group of rounded, pink, granite hills of which Gebel Hamâta forms the summit. From this group the ground slopes down on all sides, while northwards, ridge beyond ridge of dyke-centred granite extend right up to the edge of Wadi el Sheikh. Especially noticeable is this dyke system to the north of Gebel Moreia or Tarbush from whence these dykes radiate. Had it not been for their presence this area would have been, in all probability, reduced more or less to a dead level.

Passing down into Wadi el Gharbi, which heads in the mountain mass of Matab el Dêr, a tarfa grove of well-grown trees as well as some palms are found in its narrow sandy bed. Higher up there are a few ruins. A little further down is the path going to Naqb Hawa, which here descends a steep slope of one of the many terraces round about. Just beyond the entrance to the Naqb is the very narrow opening of Wadi Emlêsa, a gigantic winding defile, which, piercing far into the heart of the central mountain cluster, has its extreme source in the north-western slopes of Gebel Katharina. "Though passable to pedestrians only this wild romantic gorge deserves description as an example of the most beautiful of the mountain glens of Sinai; indeed it exhibits almost from end to end of its course a combination of grandeur with beauty seldom met with elsewhere in the country. The entry from the plain south of Wady Solaf into the hills is very abrupt, and you suddenly find yourself in a narrow, wild glen but fifty yards across, hemmed in by towering granite mountains from 1000 to 2500ft. in height. In about a mile from the mouth of the gorge, you come to a faint trickling stream fringed with abundant vegetation, wild fig trees, palm trees, high rushes and reeds; there are also old monastic dwellings, surrounded by gardens now fallen into Arab hands. As you ascend the defile, its verdure grows more and more abundant; the faint stream becomes a gladsome rivulet, here falling in spray over huge boulders or ledges of solid rock, there spreading into deep green rocky pools amid a profusion of ferns and mosses; the wady in its narrowest part is a mere cleft between gigantic overhanging walls of rock which stand in stupendous contrast to the palms and gardens in its bed; and the whole scenery, both of the gorge itself and of the deep, gloomy defiles which here and there enter from the south, abounds with features of remarkable grandeur. The vegetation reaches its highest pitch at and

near the point where Wady Bugiyeh flows in from the neighbouring pass of Nagb Hawa. Here the gardens and monastic ruins are extremely numerous; the sylvan aspect of these gardens, always beautiful, is especially so in the early half of the year, when the numerous varieties of fruit trees, bright with fresh spring and summer foliage and blossoms, present the appearance of a perfect Paradise in the midst of these savage wilds. The name of the main defile, Wady Emleisah, 'the slippery valley' (from its boulders polished by the flow of water), and that of its branch, Wady Bugiyeh, 'the valley through which water rushes with the noise of a trumpet,' are sufficient to prepare the traveller for his rough and tiresome scramble along its bed, torn and ravaged by the floods. But, from a short distance below Wady Bugiyeh, an old monastic path, still plainly marked, and in some places in capital preservation, ascends the glen and vastly aids one's progress. About two miles above Wady Bugiyeh, the valley, here bearing the

Wadi et T'lah.

name of Wady et T'lah, bifurcates; the principal and fertile branch, turning southward into the hills soon subdivides into a number of small channels, which wind up the slopes of Jebel Katharina and Samr et Tiniyeh to their sources; the other branch, scarcely a mile long, and which the old road follows, terminates in a steep rocky nagb, with an immediate descent from its crest into the Seil Leja, within a mile of the Ras Sufsafeh cliffs."

Wadi Solâf.

Leaving the entrance of Wadi Emlêsa the road leads down Wadi Solâf, a nice broad valley bounded near the head by terraces. On its right it receives several small tributaries from the low hills and open ground which compose the country between it and Wadi el Sheikh, among which are Wadi Niqwat el Amri, named after a person of that name, Wadi Qirit el Maghaddi (the valley of the village of the merry-maker), Wadi Qaban and Abu Talib, the latter named after the successor of Mohammed, while from the left it receives Wadi Emlêsa from Samr el Tinia, Wadi Hamâra from the hills north of Gebel Moreia, and Wadi Magrifat from the Fersh el Dhabb (the lizard's plateau).

The wadi affords excellent going and is clothed with a luxuriant growth of retem in its lower part, while one or two seyal grow higher up. Other plants, affording abundant food for the flocks of the numerous Bedawin who live in this wadi, grow here and on the open ground to the right. On the left rises the tripartite summit of Gebel Moreia or Tarbush, while stretching away to the west of it rise the sharply tilted ridges of gneiss ending in the neighbourhood of Gebel Ethmed and Naqb el Engawa, so-called because the dates from the palmgrove at Tor are brought to the Convent by this route. On the

right it is bounded by Gebel Um Esnân (probably named because it is much cut by black dykes, these being called "Sunn" by the Bedawin). Beyond this the right bank is bounded by the ridge of gneiss which was mentioned as occurring at the mouth of Wadi el Sheikh. Before reaching the Naqb el Engawa, the wadi, which up to the present had been following a fairly straight east-and-west course, now bends sharply north-west, then south-west, and after passing the tributary from the Naqb, bears away in a tortuous north-west course toward Ferân.

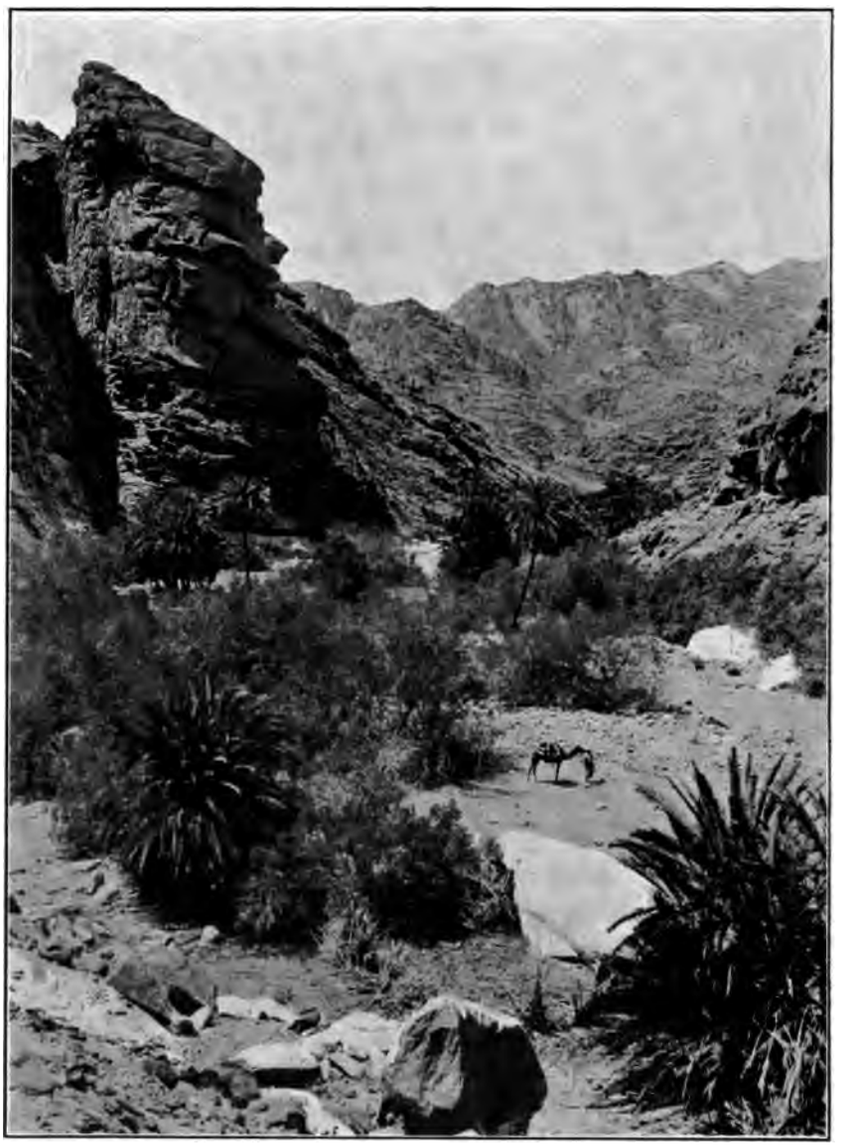
From the left it receives Wadi Um Takha from Bêdhat Um Takha, the only other tributary of importance being Wadi el Rim, which enters from the same side about 3 kilometres from its mouth. Below this the wadi narrows considerably; while above, it varied between 200 and 300 metres in width.

"Branch route to Wady Sigilliyeh.—It is about an hour's walk up Wadi er Rimm Wady er Rimm to the monastic remains at the bend of the valley; here the wady becomes impassable for camels; but from traces seen higher up, there can be no doubt that at one time an excellent mountain path extended beyond this point, leading ultimately to the now deserted and ruined monastic settlements near the head of Wady Sigilliyeh; we visited these ruins, and I subjoin a few notes of our trip, extracted from my journal. From the spring in Wady er Rimm, a walk of about a mile and a quarter up the valley, over frightful boulders, brought us to the mouth of Wady Rimm el Mahasineh; we now turned to our right, nearly south-west, and followed this valley, or rather glen, to its Wadi Rimm el Mahasineh source, three miles distant, on a rocky plateau on the eastern shoulder of the Serbal range; the glen is rough, steep and tiring, and piled with rocks and boulders, and ends in a precipitous ascent; traces of an old monastic road, well graded and in good preservation, were sometimes seen, though floods have destroyed the greater part; there were palms and trickling water in two or three places; also a few Sinaitic inscriptions, but these ceased at the foot of the last ascent, and afterwards no more were seen. On the summit, about 5,075 feet above the sea, we found ourselves in the midst of wild and awful scenery; huge shattered cliffs and peaks of granite rose on our right and left; to our right Jebel Shinenir, on the eastern flank of Serbal; to our left, Beidhat Um Takhah, Jebel Sigilliyeh, and others no less grand; beneath and before us a number of precipitous glens and ravines descended from the surrounding heights to a principal channel, Wady Sigilliyeh, which winds seaward in a deep chasm between massive granite mountains. There is a ruined building, doubtless monastic, on the summit plateau, built probably as a resting-place for weary hermits. Just beyond it,

Wady Sigilliyeh.

we plunged into a narrow ravine, falling at a tremendous angle into Wady Sigilliyeh, twelve hundred feet below. A more desperate spot for a road can hardly be conceived; it was one of the toughest pieces of mountain travel we had yet encountered; but the early monks, with an energy almost incomprehensible, had constructed an excellent path, arranged in steps and winding down the rugged slope; wherever the cataracts have spared them, these ancient steps are still intact, large flat slabs of granite skilfully and securely laid. Half way down, the steps failed us; here the floods had swept away every trace, and we had to pick our way with difficulty, and often danger, to the bottom of the ravine, amid crumbling debris and over treacherous slides of loose friable alluvium. Crossing the wady at the foot of the descent, we immediately began to mount the opposite hill-side by a continuation of the ancient path, here in a fair state of preservation, and graded with admirable skill and judgment along the steep rocky mountain ledges. Twenty minutes hard walking, and an ascent of about five hundred feet from the wadi bed, brought us to the head of a sequestered glen; and here, amid palms and wild rocks, with a tiny spring just above, trickling amongst maidenhair ferns, were the remains of one of the so-called "convents" we had come to see, consisting of no more than two or three monastic cells and gardens, all in ruins. Half a mile along the hill-side we came upon another glen and just such another cluster of ruins; and across on the opposite side of the wady, could be discerned a third and similar group, approached by a path graded along the mountain's face like that we had just ascended. The ruins are unimportant, and only interesting as having once formed the abodes of recluses so fanatical as to have made their homes in this weird inaccessible spot. But the scenery was most impressive—almost overpowering—the stupendous mountains, the utter seclusion and death-like stillness and the strangely picturesque mixture of desolation and verdure. We had a hard and weary scramble home to our tents in Wady er Rimm, three and a half hours' steady going, with but one short halt at the head of the great ravine. Our day's exploit amazed the Bedawin in camp; even Salem, our hardy guide was obliged to admit fatigue; the sheikh, Hassan Ibn Amir, evidently thought us fools for our pains, and remarked that, Arab though he was, if anything could have induced him to go so far, nothing certainly could have persuaded him to go and return in a single day."

Leaving Wadi Solâf at the Naqb el Engawa, after a walk of 2.5 kilometres, the head of Wadi Hebrân is reached, here 1,002 metres above the sea, and the water from this point makes its way down a rugged



PALM GROVE IN WADI HEBRAN.

pass into the main waterway of Hebrân. The road down to the main wadi is very bad going, being for the most part a narrow, winding, rocky path along the ledges overhanging the pass, and very difficult for loaded camels. At the water-parting there are numerous ruins called "nawamîs."

Descending the gorge from the Naqb, one sees the steep jagged peaks of Matakh el Barûd on the right, while on the left the ridges of gneiss rise one behind the other to the foot of Gebel Moreia, a doleritic neck split up into three peaks, which stand 2,050 metres above the sea.

As the wadi opens out from the pass it receives Wadi Moreia from the left, and opposite it Wadi Um Lassaf—so named because of the lassaf trees growing in it—from the ridge of Matakh el Barûd.

Wadi Ethmed.

At the point where the valley bends round to the south-west it receives the important tributary of Ethmed (so called because its water disappears in summer), which supplies a large quantity of the water which comes down Hebrân, its collecting ground being in the gneiss hills between Wadi Hebrân and Gebel Moreia. A little further down two other feeders come in from the left, viz, Wadi Morêta and Wadi Tayiba, the former heading in the large mass of red granite, Gebel Baghabuq, which lies between Gebel Madsûs and Moreia, while the latter takes its origin at the foot of Gebel Tayiba, an outlying part of the above-mentioned mass.

Wadi Kibrîn (Gabriel's Valley).

This is a fine wide wadi, also from the left, in which several goodly seyal are seen growing. It heads in Gebel Baghabuq, and running along the foot of Gebel Madsûs, bends north-west and enters Hebrân.

Inscriptions.

At its mouth on its left side there are a few sinaitic inscriptions seen on a large detached block of grey granite.

Wadi Khalaqa.

About 4 kilometres further down, the Wadi Khalaqa (name a corrupt form of Khirqa, a fissure or rift) a very narrow valley with small precipices in it, enters from the right, its source being in Gebel Matakh el Barûd. Beyond this some very well-grown seyal trees were passed, and then Wadi Wêber entered from the left from its source in the hills between Wadis Hebrân and Meâr.

Wadi Emlaha.

A little further down Wadi Emlaha enters from the right. It receives its name from the brackish water found in it. About 4 kilometres further down Wadi Khurr (i.e., a channel caused by the continual dropping of water) enters from the left from Gebel Khurr. Down to this point the main wadi has been fairly wide and straight, its width varying from 80 to 100 metres between fairly steep sides of grey granite. From its head down to about 9 kilometres from its mouth the wadi is occupied mainly by seyal trees. Below this point, tarfa and

palms take their place, while running water appears. In many places the tarfa bushes fill the wadi, while a few lassaf are seen on its sides. The stream occasionally opens out and forms nice little clear pools in which *Veronica beccabunga*, reeds, bulrushes, mint, and a few other plants grow. About 4 kilometres from its mouth the valley narrows to about 40 metres, and becomes a winding gorge, which in many places in less than 20 metres wide, while the going is rather rough amongst sand and boulders. This character may be said to belong to the whole wadi, the road being much improved where the Sikkat Abbas Pasha, which runs along it still remains intact. Towering over the gorge are precipitous cliffs 150 to 200 metres high, on those sides marks are seen showing how high the winter torrents occasionally rise.

Climbing a hill above this pass, a good view of the surrounding country can be obtained. To the north, in the foreground, one notices Gebel Illimiana, between which and Gebel Wirqa the Wadi Wirqa enters the plain. Beyond Wirqa is the plateau-like mass of granite, the Fersh el Ramûz; while further to the north is the red granite mass of Gebel Siqillia with Gebel Serbâl towering behind. On the north-east, Gebel Moreia with Gebel Madsûs on the east, form the two prominent features of the landscape; while away to the south stretches the high plateau of hills which culminates in Gebel Um Shomer. The hills bounding Wadi Hebrân are mainly composed of grey or pink granite which is much cut by dykes; while away to the north, gneiss hills form the green plateau which is called the Fersh el Dhabb.

It is now necessary to diverge from the direct line followed hitherto to give a short description of the hills and wadis which lie on the border of Qâ between Hebrân and the limestone plateau to the north-west.

Wadi Illimiana. Passing north the first wadi reached is that of Illimiana, only a short valley heading in the hill bearing its name.

Wadi Wirqa. The next is that of Wirqa which is a more important drainage line. From the top of Gebel Wirqa, which is 994 metres above the sea, the course of this wadi is seen plainly. Near its mouth it has the gorge which characterises so many of the wadis which enter El Qâ, but after passing through the granite band it enters a patch of low hills where it opens out. In it were seen water, palms, and seyal trees. At no part of its course did it seem to be very wide, but it receives a large part of the water from Gebel Siqillia on its way from its head in the Fersh el Dhabb.

Wadi Ramûz. The next wadi to the north is that of Ramûz, the name meaning a secret spring. This is a short wadi which heads behind Gebel Ramûz in the Fersh Ramûz. In it are a few palms and a small but good well

of water, while a little further up, the way is blocked by a precipice of granite about 13 metres high.

Between Wadi Ramûz and Wadi Geba rise the hills of Ramûz, 800 metres, and Geba, 933 metres above sea level. In this valley there is a perpetual stream of water running over the waterfall at its mouth. Wadi Geba.

"This wadi presents from end to end of its course a scene of uncommon magnificence and beauty. At its mouth giant cliffs frown down upon a narrow chasm, in many places scarcely thirty feet in width, through which the drainage of nearly the whole southern slopes of Mounts Serbal and Sigilliyeh breaks by a succession of leaps into the plain below. The scenes here at flood-times must be almost terrible. As we saw it, the stream was no more than a trickling rivulet, with large pools every here and there; but the smooth waterworn appearance of the cliffs for twenty or thirty feet upwards on either side of the pass, and widespread signs of devastation in the plain beyond, served to convey a faint idea of what those scenes must be. Higher up, the valley expands into a wild romantic glen, hemmed in by naked granite mountains of stupendous height. A pavement of pink or grey granite, polished by the rush of waters, forms its bed, and piles of monster boulders here and there encumber the path. A clear perennial stream winds down the ravine, now rippling over smooth slabs of rock, anon spreading into deep green pools, or falling over boulders and ledges in tiny cascades which sprinkle numbers of ferns growing in shady rock grottoes with their foam. For want probably of sufficient soil, there are no palms in the valley, but an abundance of marsh plants, bright green herbage, and waving rushes ten or twelve feet high, flourish by the brook side. The whole scene is a charming strange mixture of the savage and the peaceful. Every bend in the glen reveals some new and surprising prospect; at every turn you pause to admire the bold forms and glowing tints of the surrounding mountains, and the grand rugged cliffs of Serbal closing the distant view. From the blank and horrible desolation of El Gaah, to come suddenly into a valley so beautiful as this, with shade, water and verdure, and majestic features of scenery, is a treat of the rarest kind. As if to complete the contrast, signs of life are here abundant and add much to the romantic loneliness of the scene; footprints of leopards mark the gravel by the water's side in such numbers that one cannot help wondering how so many of these creatures can possibly find subsistance in the desert; tracks of ibex, too, are very numerous; little brown desert partridges scurry over the naked rocks; and locusts, dragon-flies, and winged grasshoppers of enormous size, skim through the air."

Wadi Meâr. Returning south again, the next wadi below Hebrân is that of Meâr. The mouth of this wadi is filled with boulders, and is very rough indeed. Out in the plain deep ruts have been cut by the torrents, and a huge mass of boulders is piled up, round which the water makes its way in different channels. At first the wadi is fairly wide, but it very soon narrows into a gorge with perpendicular sides of a dark diorite, 300 metres high, veined in every direction by white granite, being cut as well by dykes of dolerite and quartz-felsite. Here the gorge is little more than 20 metres wide. Just above the gorge the wadi widens suddenly, and one comes on several streams of running water which suddenly lose themselves in the sand. In the middle of the wadi, slightly above the water, is a fine grove of well-grown, spreading seyal trees which is evidently much used as a camping place by the Bedawin. On the right side of the wadi are several small enclosed gardens, which are watered by shaduf from the stream near by; palms and various vegetables being grown there. Besides the palms, there are sidr trees of great size, groves of tarfa bushes, and numerous representatives of the "*ilban*" (Towara), "*yessar*" (Maazi) and "*moina*" (Ababda) whose great resemblance to the mountain ash made it an ornament to the valley. For about 5 kilometres up, the wadi was filled with tarfa trees, which practically obscured all the view, but beyond this point they were replaced by the "ilban". From the gorge upwards the wadi varied from 100 to 200 metres wide, and the bed was rather rough and bouldery, there being only the faintest path visible.

Wadi Meqênus. On the way up a few unimportant feeders were passed, the largest of which was Wadi Ghueb. But the first important tributary is that of Wadi Meqênus (the hunter's valley) which comes in from the left bank from behind Gebel Meqênus. It is a rough wadi impassable for camels, and filled with huge boulders and cataracts over which one has to climb. The sides of the hills here bear a few small trees and shrubs; of the latter one was a spiny plant with two small rosettes of leaves to each spine called "*oshad*", while the other resembling "*arta*" is called "*alda*". Several pools of water were found in this wadi as well as numerous "ilban" trees. Gebel Meqênus, which is 1,007 metres above the sea, is evidently the turning point of the water between Meâr and Ilti, as all the streams go down from it into the latter.

Between Wadi Meqênus and Ilti the main wadi is fairly straight. Near the mouth of Wadi Ilti, Meâr widens out, a large terrace marking the junction between the two wadis. Wadi Ilti near its mouth has a westerly direction, but after winding in and out amongst huge boulders of granite for a little, it suddenly bends round until its course is almost

Widi Ilti.

due north and south. Here it is better footing but very sandy, and after going through a narrow pass of rock it opens out somewhat, the hills on either side being less steep and high. Just above the pass the wadi makes a U-shaped bend and then bears off to the south-east; pools of water in smooth rock basins were seen, with a babbling stream feeding them; while around them are numerous bulrushes and palms, and near by are some old ruins. Higher up the wadi, which was no longer passable for loaded camels, were several clumps of palms up to which a footpath led along the side of the hills. After passing Gebel Sawasia this wadi rose rapidly and soon ended in the side of Gebel Ilti.

Gebel Sawasia.

To the east of this wadi rises Gebel Sawasia, a high hill composed of granite at the base, but terminated by a steep neck of dolerite at the top. Climbing it, it was found that where the granite ends and the dolerite begins the sides are almost sheer up and down, very slippery and polished so that it could only be ascended on hands and knees. This hill is evidently the Gebel Ilti of the Ordnance Survey, but apparently they have gone somewhat astray here, as a large wadi is also shown which does not exist.

By the Ordnance Survey the height of this hill was given as 6,480 ft. or 1,975 metres. On its eastern side it overlooks Wadi Khrêta, ending in a sheer precipice 1,280 metres high. From the top of this hill a good view is obtained of the surrounding hills. To the south could be seen Gebel Shiddiq, and beyond it Gebel Um Shomer, which, from this point of view, does not look very imposing, the surrounding hills taking away from its height; while to the west are seen Gebels Meqênus, Ilti, and Abu Hagab, forming a sort of plateau sloping up and ending in the ridge of Wiqran and Giddet el Ela (the mountain of high dykes). The upper portion is much cut up by well-marked black dykes (called "giddet" by the Bedawin); to the north the plateau-like character is continued beyond Hebrân, until Gebels Illimiana, Wirqa, Siqillia and Serbâl suddenly break the general level of the surface; while bearing round to the west are Gebels Tayiba, Madsûs, with the peaks of Moreia in the distance, Baghabuq and Um Saha occupying the foreground, the latter coming almost up to the side of Wadi Khrêta. Beyond the jagged mass of Um Saha and forming the skyline, could be seen Gebel Qasr Abbas Pasha (Samr el Tinia of the Ordnance Survey) with its ruined palace clearly visible, Gebel Katrîna, Zebir, and Abu Rumêl, while nearer is the black range of Koli and Um Iswed, which approaches and eventually forms the wall of the Wadi Siq on the north and Khrêta on the west. Returning down Wadi Ilti, at the point where it meets

Meâr, there is a bold spur from Sawasia which ends more or less perpendicularly, and is continued up the wadi until, opposite Gebel Madsûs, it forms a steep, overhanging cliff.

Gebel Madsûs. This is a large black hill with a rather blunt top, its sides much seamed with ravines, and so steep as to render it inaccessible from Wadi Meâr. It is composed of a neck of dolerite and it is to this that its inaccessible nature is due. The drainage from it is brought down by Wadi Rahu.

Nearly south-east from Gebel Madsûs, Wadi Meâr bends round from its east-and-west line towards the south-east, and makes its way over bouldery, rough ground along the foot of Gebels Um Saha and Hamêdha, where there are numerous high terraces of piled up boulders, evidently the work of the various tributaries which come in from the right bank.

A little farther on Wadi Meâr ceases, having split up into two branches, the main one continuing in the same course being called

Wadi Siq. Khrêta, while the other, Wadi Siq, comes in from the high land in a south-of-west direction. The latter, which at its head is called Wadi Otha, heads in Gebel Abu Rumêl, and receives from the right Wadi Tayiba from the hills behind Um Saha, and opposite it on the other side, Wadi Abu Zarqa, from Gebel Koli; while further down nearer the mouth, Wadi Qên comes in from the right from Um Saha. Wadi Siq is a fairly open valley which rises somewhat rapidly towards its head, but does not seem to present any obstacle to its exploration. Some well-grown seyal trees were seen near its mouth. At the fork between Wadi Siq and Khrêta there is a spur of the dolerite ridge of Abu Mezeraq (father of blueness), Koli and Um Iswed which forms more or less vertical sides, especially towards the latter valley.

Wadi Khrêta. From its junction with Wadi Siq this valley rises rapidly towards the high lands to the south. To the east it is bounded by the steep-sided dolerite ridge of Gebel Koli, etc; while on the west it has the plateau called the Fersh Abu Loz, from which it receives Wadis Marzeqa and Main. Higher up it forks, the western branch taking the name of Wadi Murr, which in turn is replaced by that of Zeraiqia, which heads in Gebel Zeraiqia and Abu Shejera, while the other, preserving the name of Khrêta, bends off to the east and heads in Gebel Zahir.

Fersh Abu Loz. From the fork of Khrêta a winding path for donkeys and camels leads up to the plateau called the Fersh Abu Loz (the almond plateau). This extends for a good distance reaching to the foot of Giddet el Ela. On the top, 1,064 metres above the sea, were the withered remains of numerous plants, while many bushes of retem and a tarfa tree were found on it. During the rainy season the water evidently collects in

shallow pools on the surface and deposits its mud, and in a short time the place is covered with verdure. The Bedawin take up their goats, sheep, camels and donkeys, and camp there as long as the food lasts. To the south-east of Giddet el Ela is a pass, the Naqb Abu Loz, between the Fersh and the drainage which joins Wadi Shiddiq. From the fork of Khrêta and Murr, down to a little below the junction of the former with Siq, a distance of 12 kilometres or so, the wadi fell 305 metres. Its bed offered a fairly good path and was well clothed with retem, which further down was replaced by seyal trees, they in their turn giving way to the "ilban," while near its mouth the tarfa tree held sway. There is thus a fairly well-defined zone-system to be noticed amongst the plants and trees of the wadis, this being observed in all the main valleys of the western side of the Peninsula of Sinai. This wadi is fairly well populated by Bedawin, a fairly numerous encampment being noticed at the mouth, another about half-way up, while a third was in Khrêta, at the foot of the Fersh Abu Loz. There is plenty of water to be found in the side wadis, and as there is also plenty of grazing, the people lead a very easy life, the men doing nothing except going out hunting or paying an occasional visit to El Tor or Suez.

Naqb Abu Loz.

Leaving the mouth of Wadi Meâr and turning south, the edge of Gebel Hagab and Wiqran is skirted, the mouth of Wadi Wiqran, which drains these hills, being also passed. This is a very narrow, steep and rocky valley, which soon terminates in the hills behind.

Gebel Wiqran
Wadi Wiqran.

The first wadi of importance after Meâr was that of Shiddiq (the valley with the wide mouth). It is well named, as it has a very wide entrance, which rapidly narrows as the wadi is ascended. In the plain are several seyal trees. Going up the wadi is extremely difficult on account of the huge boulders strewn in its bed. Not far up several pools of water were found which were said to be perennial, water trickling out of the rock above them keeping them constantly supplied. Numerous plants were found in this valley in the vicinity of the water. Over the pools flitted brilliant-coloured dragon-flies, while from shady nooks under the rocks the beautiful maidenhair fern peeped out. Lasaf was also met with, as well as "hammad," the wild fig, while near the pools "habbak", one of the mint family, an infusion of which is used for dressing wounds, and "hazam," the wild mignonette, are met with. This wadi is not practicable for camels except for a little way. Higher up water and palms are said to exist.

Wadi Shiddiq.

Standing on a hill overlooking this wadi, the drainage area is seen to be more or less basin-shaped. On the north side the edge is formed

by the ridge of Wiqran and Giddet el Ela, while on the east the steep ridge, of which Gebel Shiddiq forms the lower peaks, and which culminates in the majestic crest of Um Shomer, forms the watershed, and its southern boundary is a long ridge running down from the latter hill.

About two thirds of the way up, the wadi forks, one branch going away northwards towards Naqb Abu Loz, while the other goes eastward to Gebel Um Shomer.

Wadi Emlaha. Leaving Wadi Shiddiq, several small drainages are passed in which are plenty of different plants such as bowal, rimth, etc., as well as a few seyal trees, and after travelling about 13 kilometres down the plain, the mouth of Wadi Emlaha is reached, which at its entrance is blocked with huge terraces through which the water has cut perpendicular-sided gullies. In addition to these terracos in the wadi itself, others also occur perched high up the sides of the hills, in some places filling up tributary valleys. At the mouth of the wadi there is a good well of water.

Wadi Emlaha is impracticable for camels for any distance up, on account of the small waterfalls of polished rock, which bar the way even for pedestrians. Higher up several good deep pools of water surrounded by bulrushes and other plants occur. The bed of the wadi being of loose sand, in which are many huge boulders, makes walking very fatiguing. The scenery up this valley is very fine, the wadi being only about 30 metres wide, and shut in by sheer cliffs of grey granite which rise between 200 and 300 metres above its bed. Looking up towards Gebel Um Shomer, from whence this wadi comes, a grand view of this fine hill is obtained. From the wadi it rises away in a sheer cliff, which eventually breaks up into a series of jagged peaks rising one behind the other, and culminating in the huge cubical crest which distinguishes that hill from this side.

From the mouth of Emlaha, a footpath practicable for camels goes up on to the low foothills, and leads into the higher reaches of the wadi.

The general aspect of the country is that of a high central range of peaks which culminates in that of Um Shomer, falling away to the north and south, while to the west the foothills gradually run down almost to the level of the plain. Leaving this wadi, the road led down the plain past the mouth of Isli which will be described by the other Survey party who went up it.

Wadi Themelli Three kilometres south of Isli the mouth of Wadi Themelli was crossed, which heads in the hill bearing the same name. It is little more than a gully, and is far too rough to ascend, but its course could be made out fairly well from the top of a hill which overlooks it.

About 3 kilometres farther south Wadi Abu Gorf was passed, so called because of the patches of sand and marl which are attached to its sides. This is, however, quite a characteristic of all the wadis in the region. On the right bank of this valley, and about 2 kilometres out in the plain, stands a very conspicuous two-peaked hill visible as far north as the Wadi Hebrân, called Qerain Utud (the horns of the kid) because it actually resembles in appearance the budding horns of a kid. This hill is the first of the outlying masses of granite, etc., which are met with further south in the coast plain. Wadi Abu Gorf. Qerain Utud.

Further on is Wadi Theman, a short, wide-mouthed valley which suddenly ended in a few narrow gullies heading in the neighbourhood of Gebel Theman. Near its head this wadi receives another, the Wadi Sifsaf. Beyond this valley there is a maze of isolated hills in the plain, the most important of which is called Gebel Um Rieh (the mother of wind). This hill takes its name from the small wadi which drains it, and heads in a hill bearing its name, one of a secondary range which lies at the foot of the one forming the watershed. Wadi Theman.

The next important valley is that of Wadi Um Hash, about 11 kilometres further south, which at its mouth is practically a plain, but narrows rapidly to about 200 metres. At its mouth it receives Wadi Um Rewas from the neighbourhood of Gebel Um Sidr. This wadi was full of "bsilla," and there were numerous Bedawin with large flocks of goats and sheep feeding in it. Going up it towards the watershed, it suddenly narrowed where it received Wadi Girgir. This wadi enters through a pass of red granite, and just above this a stream of water was met which disappeared in the sand. Further up numerous pools of water were met with, and several palms were also seen, while nearer the head the whole valley was filled with water from side to side which rendered ascent impossible. On the sides of the wadi were numerous terraces hanging high above the present bed, and these could be seen extending to the water-parting at the head of the valley, the highest of them being over 900 metres above sea-level. Wadi Um Hash.

From Gebel Um Shomer down to this point the same type of country has prevailed, viz., a high watershed range, with a secondary range at the foot of it. A peculiarity of the latter is that it forms in many cases a secondary water-parting, the drainage often passing north and south for some distance until it can find a way through to the plain. This would seem to suggest that this interruption is in all probability the work of a fault which has let down the foot-hills, and the line of fracture being one of weakness, it soon became the path of all the drainage from both ranges.

Beyond Wadi Um Hash these distinctive characters are lost, and the range becomes broken up into a group of separate hills or peaks.

Returning down Wadi Girgir a path was found running over a low ridge from Wadi Morit, a feeder of Um Hash, into Wadi Tihi. It was in it, while engaged in mapping on Gebel Tihi, that a Sinai thunderstorm was first experienced. From the hilltop big banks of black angry-looking clouds were seen rolling up the watershed, and it was hoped they would pass on, but suddenly a second mass was seen coming up the hills in a direct line with our station. Instruments were hastily stowed away, and a rush was made for a slightly overhanging rock more than half way down, which was reached just as the first peals of thunder were heard. Scarcely had we got ourselves safely stowed away, when the raincloud which had been seen travelling in our direction, was upon us. Rain and hail descended in sheets, and for a time the surrounding hills were blotted out as by a mist, while ever and anon the scene was lit up by a blinding flash of lightning followed by a deafening crash of thunder. Soon the sound of rushing water was heard, and each gully could be seen pouring down a white frothy mass into the main wadi, down which a stream of water carrying pieces of wood and other debris was seen rushing. The storm only lasted about a quarter of an hour, and it was evident that the centre had not passed over us, for our camp, only 3 or 4 kilometres farther on, escaped it entirely. What a really severe thunderstorm is like is described by Mr. Holland.*

Wadi Rashid.

The next important wadi is that of Rashid, which at the mouth is over a kilometre wide, and higher up widens into a plain in which are many terraces. Into this from the right flows a small wadi—Abu Bir—while opposite it there enters Wadi Abu Tarfa, so named because of the tarfa trees growing in it. Above this the valley is full of boulders which make very bad going. Climbing Gebel Letih, a hill on the south side of the wadi and forming the watershed, a good view of the surrounding country was obtained. Away to the east, through a mass of detached hills, could be seen the Gulf of Aqaba, with Sherm Bay and Ras Mohammed stretching towards the south, while immediately below is the mass of low hills drained by Wadi Mokateb, Um Khashm, Um Gatih and Abu Markh. To the north a good view of Gebel Tihi and the course of drainage from it was also obtained, while below to the north-east stretched the Wadi Letih which falls into Aqaba. This wadi heads close to that of Wadi Morit.

* "Ordnance Survey of the Peninsula of Sinai," Part. I, p. 226, et seq.

Passing out of Wadi Rashid, in side valleys whose there is plenty of water, the way lay between an isolated mass of red granite—Gebel Hanasia—and Gebel Mokateb, part of the foot-hills of the watershed range. Lying well out into the plain is another mass of granite, Gebel Masraia, which is connected to the main mass by a series of outliers. After passing these, the hills take a sudden bend to the east where Wadi Abu Markh (in which trees of that name occur) comes down from Gebel Abu Markh. This wadi exemplifies the remarks made earlier about the lateral valleys which occur between the main range and the foot-hills.

Wadi Abu Markh.

Passing southward across the plain, the Wadis Sahara (valley of the sunstroke), from the hill of that name, and Moket el Dhib were crossed, and then that of Um Malaqa was entered. At the point where it enters the plain this wadi passes through a fairly narrow gorge in granite, but above this it opens out into a small plain which is very rough and stony, from which it again narrows, as it nears its head in Gebel Um Malaqa. In this wadi occurs the last water until Bir Sherm is reached.

From this point the hills become much lower, the red granite which nearly always forms the highest hills suddenly coming to an end in Um Malaqa. The continuation of the watershed is Gebel At el Gharbi, which is a series of sharp peaks of dolerite, quartz-felsite and diorite, and is continued by Gebel Madsus and Tima, a jagged ridge which ends against a plateau of red granite sloping towards the Wadi Khashaba.

Gebel At el Gharbi, etc.

This range is drained by Wadi At el Gharbi which heads near the base of Gebel Um Malaqa. Between it and Wadi Um Malaqa there are no hills, the water being parted by a slight rise in the plain. This wadi is the first to show a southward tendency in its drainage, and this is much more accentuated in the last wadi to be described, viz., Wadi Khashaba. From the former a path leads over some low ridges of quartz-felsite into Khashaba.

Wadi At el Gharbi.

This wadi is a wide shallow valley between a low granite plateau on the east, and a sharp-peaked ridge of sheared and unsheared felsite. On either side are small deposits of sandstones, much current-bedded, in the mouths of all the small, narrow, steep-sided watercourses. This wadi runs practically south-east until near its mouth it strikes a hill of harder rock, which heads it off to the south, where it passes out to sea between the igneous rock and a small hill of coral reef.

Wadi Khashaba.

In this valley and Wadi At el Gharbi, there are a few well-grown seyal trees, especially in the former near where it enters the sea. In all the

wadis, bsilla was fairly abundant, and the camels were never in want of fodder.

At the mouth of Khashaba there is a large sand-dune which blocks the way to the headland of Mohammed, the only path being along the beach for several kilometres.

The following conclusions may now be drawn from what has been already written.

1. That the peculiar lateral drainage noticed between the main range and the foot-hills is the direct result of an earth movement.

2. That, in general, the direction of the wadis is from north-east to south-west; the only marked exceptions to the rule are those of Wadi Solaf and El Sheikh, they flowing in a north-westerly direction.

3. The sudden break in the mountain mass between the Gebel Musa massif and Serbal is directly due to the geology, the rock present tending to weather easily and form plains.

4. The plain of Debbet el Ramli has been formed by the scour of the north-west wind acting on the sandstones and removing them, thus at the same time giving rise to the escarpment of El Ti.

5. The plain of El Qa, with the limestone plateau, is the result of a large fracture which has let down the ground to the west.

6. The enclosed valley of El Araba, with the parallel ridges, owe their origin to the differential weathering of the soft Nubian sandstone, and to the alternation of marls and limestones in the series.

7. It is probable that the general direction of the wadis has been determined by lines of fold or fracture since the general trend of the dykes is in a north-east-south-west line.

4. METEOROLOGY.

Up to the 6th November there was a decreasing temperature, then a rise with sudden fall followed again by a rise which continued to the end of the month. During December there was a steadily falling temperature which culminated in the first week of January, 1899, in a severe frost for about a week, the lowest temperature occuring on the 4th. From this date there was another gradual rise, a maximum being reached on the 4th of February, followed by a rapid fall on the 7th, this being followed by another rise and corresponding drop to freezing point on the 21st. From this date until the 20th March the temperature was equable, a sudden fall taking place on this day followed by a steady rise to the end of the month.

During the five and a half months occupied by the survey rain fell on twenty days, on eight of which it rained heavily, and one day snow fell. Hoar-frost was seen on six different days. During the months of October and November thunderstorms were very frequent, while in the following March they were again prevalent.

There were thirty-five cloudy days, while during several others the sky was overcast for a time. Wind was prevalent along the coast during the month of December; but at the end of February and during March there were frequent gales and sandstorms. The prevalent wind is north or north-west, but in the early part of the year strong south-east winds, very hot and unpleasant, were experienced, similar to those met with in the Nile valley. On the sea-coast a strong north-west wind usually blows every day.

On the other hand when a south-west wind blows it generally brings rain.

5. NATURAL HISTORY NOTES.

As the botany of the Peninsula of Sinai has been very thoroughly done by Dr. G. Schweinfurth and others it is not intended to enter into a detailed account of the different plants met with, many of which were collected and dried, being afterwards named for me by the courtesy of the former. It is enough to indicate the places where the plants were most abundant. In the wadis to the east and south of El Tor many plants are found wherever a water-pool or trickling stream is met with; but the places par excellence where flowers are in most abundance are the wadis draining the high-lying plain of Debbet el Ramli and Gebel el Ti. In these, plants are met with in abundance, clothing the wadis and sides of the hills with a many-coloured carpet which looks all the more refreshing if one has just left the barren coast-plain. But the thing which especially arrested my attention, and which has not to my knowledge been previously noted, is the well-marked zones into which the main trees and bushes divide themselves, these being determined by altitude above sea-level. Thus, speaking generally, the seyal and tarfa trees are not found above 427 metres above the sea, while next in order comes the "ilban" (Towara) "yessar" (Maazi) "moina" (Ababda), which gives place to the retem at 722 metres, the latter persisting up to the watershed. This statement of levels means that the last tree of the kind under consideration has disappeared, but there is a certain altitude common to any two for a certain distance.

It must be pointed out however that it seems possible, where the conditions of soil and plant-food are favourable, for plants to exist far above their usual altitude, this being seen in the tarfa groves in Wadi el Sheikh and El Gharbi, where the soil was a rich-looking marl.

Animals. Passing to the animals, amongst the mammals, the ibex is the most common, being seen several times in numbers from two to ten together. Gazelle were only seen once or twice and seem to be much less common than the ibex. Leopards occur all over the high plateau and though none were actually observed, yet fresh tracks were met with several times and one was seen by the Bedawin approaching the camp in Wadi Sheqer. They are much hated by the Bedawin on account of the loss in camels caused by them each year. The day previous to that in which the camp was pitched in Wadi Sheqer, a camel was killed by a leopard quite close to the camp. Wolves and hyenas are also found in the sedimentary area. Hares were frequently started in the wadis round the Debbet el Ramli, on the northern half of the peninsula, but none were seen in the south.

Hyrax also occur in different wadis. Snakes were very rarely seen during the period spent in the country; whether it was due to the cold weather, or only because they were few in number is difficult to say. Only one *Cerastes* was seen and killed at Ras Mohammed, the others were of a harmless variety.

Numerous eagles abound in the hills, as many as forty were seen sitting on a small hill near the camel which was killed by the leopard in Wadi Sheqer, one of which having been killed was found to have a stretch of wing of 2·5 metres.

Ravens were fairly common. Peregrine falcons also were seen in the cliffs bordering the Debbet el Ramli. Two kinds of partridges were seen frequently in the northern half of the peninsula ; these have been described and figured in the Report of the Ordnance Survey of Sinai Pt. I.

Numerous chats were also met with in all the wadis, as well as many wagtails.

Water Supply. Except in the coast-plain between Suez and Wadi Gharandel, and the range of El Araba and Qa plain, water-supply need cause no anxiety to the traveller. In the main hill-mass water occurs in nearly every main wadi as well as in many of the side ones. In all the big mountain masses like Serbal and the Sinai massif water occurs in many rock-pools (often of large) size which are available all the year round, but in many of the wadis there are running streams, e.g. Wadi Geba, Wadi

Etla, etc. In the igneous ranges the water is good except where it rises from the bed of the wadi when it is often brackish and unpleasant-tasted. In the sedimentary area the water is often of a distinctly saline nature, in some places, as at Wadi Tayiba and Ethâl, being extremely brackish and unfit for drinking. In Wadi Gharandel the water is very evil-smelling and bad-tasted in spring, but said to be sweeter in winter. There is a plentiful supply of water here.

PART II.

GEOLOGY.

INTRODUCTION.—In dealing with this part of the memoir, it is necessary to notice the previous work done on the district under description, giving the conclusion arrived at by the various authors, and discussing and comparing their results as they coincide or diverge from those to which the writer has been led.

This district has been visited by several well-known geologists, e.g., Russeger, Fraas, Rothpletz, Bauerman and Le Neve Foster, Holland, Hull, Walther and Blanckenhorn, all of whom have published their conclusions. It is to Walther that geologists are indebted for the largest amount of individual work, and the most complete map hitherto published. Although not agreeing with all his deductions, it is impossible not to admire the way in which he did his work in the limited time at his disposal.

It is to Bauerman that the credit of the discovery of the Miocene and the faulting of the Carboniferous in Wadi Nasb is due. In the working out of the Miocene his work has been supplemented by Rothpletz and Blanckenhorn.

Russeger was the first to attempt a detailed account of the rocks, and though he made some mistakes as to the relations of the Eocene and Cretaceous rocks, they were quite allowable in the state of geological knowledge then existing.

In this memoir the geology is described under the following divisions:—

SECTION I.—Recent and Pleistocene deposits.
„ II.—Pliocene and Miocene beds consisting of conglomerates, gritty limestones, and gypsum.
„ III.—Eocene.
(*a*) Upper or Bartonian.
(*b*) Middle or Parisian.
(*c*) Lower or Suessonian.
„ IV.—Cretaceous limestone and shales.
„ V.—Nubian Sandstone.
„ VI.—Carboniferous.
(*a*) Sandstone.
(*b*) Limestone.

SECTION. VII.—Faults and Folds.
„ VIII.—Igneous and Metamorphic Rocks.
(I) Igneous Rocks.
1. Granites.
2. Syenites and Diorites.
3. Dykes and Veins.
4. Lava Flows.
5. Volcanic Necks.
(II) Metamorphic Rocks.
1. Gneisses and Schists.
2. Garnetiferous Schists and altered Sandstone.
„ IX.—Economic geology.
„ X.—Denudation and Weathering.

SECTION I.—RECENT AND PLEISTOCENE.

Plain of Qâ.—In describing the deposits in this plain, and the wadis which flow into and across it, it is convenient to divide it into two parts (a northern and southern), the imaginary boundary between these being a line joining El Tor and the mouth of Wadi Shiddiq.

Taking the southern half first, the deposits can be divided into two fairly distinct groups, the eastern one being of fluviatile and partly of lacustrine or marine origin, while the other is entirely marine.

The eastern part, opposite the mouth of Wadi Shiddiq in the middle of the plain, is composed of sandy clays, evidently lacustrine or fluviatile, and derived in all probability from the disintegration of the Cretaceous Marls higher up, beneath which comes the marly limestone of marine origin which forms the floor of El Wadi. Nearer the hills this sandy clay gives place to sand and gravel, which gradually becomes coarser until it is a mass of granite and other igneous boulders mixed with blown sand.

Wadi Shiddiq. At the mouth of Wadi Shiddiq large mounds or gorfs of granite boulders occur, while further up the valley, and perched on its flanks, are patches of sand and gravel often presenting vertical sides. In the floor of the wadi itself there is a layer of these gravels which is bound together into a conglomerate by a calcareous cement.

Wadi Emlaha. Along the flanks of the hills are mounds of consolidated sand, evidently part of the same series. At the mouth of Wadi Emlaha large masses of gravel and boulders are piled up, through which the water has carved a path with vertical sides, which are now about 20 metres

high. On the flanks of the hills forming the wadi walls, masses of sand and igneous gravel are seen perched on either side as much as 31 metres above the bed of the valley. These in all cases exhibit fairly distinct bedding, and almost vertical sides, and suggest the idea that they have been deposited in the valley during a period of subsidence, the water afterwards cutting its path through them and the underlying rock as the land again rose. Higher up the valley, patches of a gritty sandstone composed of pieces of felspar, granite boulders, etc., are seen attached to the sides of the wadi between 30 and 40 metres above its present bed.

To the north of the wadi, higher up amongst the hills and about 4 kilometres from its mouth, a patch of this same sandstone, false-bedded, bent in various directions, and dipping east and west at angles varying between 5° and 8°, is found filling up an old valley. At one place where its escarpment was free from sand, it was found to be between 60 and 70 metres thick, and to be 689 metres above sea-level.

Wadi Theman.

Further to the south, between Wadis Themelli and Theman, sand-rock was found capping the hills 424 metres above sea-level, while in the latter valley the same kind of sand and gravel patches were seen perched on its sides in the manner above described.

Wadi Um Hash.

The next important valley—Wadi Um Hash—has big banks of bedded sand and gravel at its mouth, and similar patches stuck on its sides, through which the water has cut its way. Higher up, where it changes its name to that of Girgir, bedded masses of gravel and sandy clay are perched high on its sides, and continue right up to the watershed at an elevation of over 915 metres above the sea.

Wadi Rashid, Um Malaqa, Ât el Gharbi.

At the mouth of Wadi Rashid large banks of sand-rock also occur stretching down on either side into the plain, while the same is observed in the valleys of Um Malaqa and Ât el Gharbi, in all three wadis the sand-rock being found on their sides besides lying in the hollows of the hills.

The plain.—At the point where the neck of Ras Mohammed widens out into the mainland a few small masses of coral-bearing limestone occur. Except for these the main mass of the plain is covered with igneous downwash from the wadis, now largely covered over with blown sand. No dunes occur, but the sand is distributed in small ripples which make walking very difficult.

The western or sea-coast part.—Starting from the neck of Ras Mohammed, where sand with fossil corals and shells occur, a flat expanse

of sand and sandy clay containing much salt, which has evidently risen very recently from the sea, as it contains shells similar to those found on the shore, begins where the former shades off into the plain. This, at first very narrow, rapidly widens out to about 2·5 kilometres, persisting at this width for about 7 kilometres when it is again restricted to a little over one. For 12·5 kilometres it continues like this, and then narrows down to a mere strip, the blown sand of the plain having encroached on it. After traversing about 13 kilometres more, it again widens out to about 2 kilometres, and continues of very irregular width, varying from a half to two kilometres for 20 kilometres further north from whence, until within 5 kilometres south of Gebêle, it maintains an average width of 1·5 kilometres, and then gradually dwindles to nothing at that village.

At the point mentioned as about 5 kilometres south of Gebêle a change comes over the plain deposits. Low mounds rise up from the edge of this saliferous clay, consisting of angular pieces of limestone and pieces of shells, suggesting in their appearance a "raised beach."

Qrum. After passing over a sandy stretch of low ground lying at the foot of the low knolls to the east of Gebêle, about a kilometre to the south of the village of Qrum, a deposit of a granite sand bound together by salt and some carbonate of lime is reached, which contains numerous recent shells of every description, as well as some reef-building coral. This deposit is almost identical with that on the beach near Gharib Lighthouse, the fossils of which have been determined as Pleistocene at the Natural History Museum, London. It is this deposit that Walther marks as Miocene in the map which accompanies his "Korallenriffe der Halbinsel der Sinai." This is somewhat strange, seeing that the shells are the same as those on the shore, and the corals are also the same as those found in the sea close by. This deposit lies under the Quarantine Enclosure, and extends from the sea to a distance of 3 kilometres inland, while its northern boundary is a line due east of El Tor; in all it occupies an area of 9 square kilometres. To the east of El Tor this sand is full of different kinds of pelecypoda, but gastropoda are rare, while in places masses of coral occur. It is also present in a patch to the north-west of Tor close to the sea-shore.

* Fourtau, in his paper on Western Sinai, gives a diagram-sketch of the beds which underlie the plain at Qrum. his knowledge being derived

* "Bulletin de la Société Khédiviale de Géographie," 1898. V^e^ série, No. 1, pp. 19-20.

from various wells sunk in the vicinity. According to him, the following beds are met with in descending order:—

Top.

1. Granite sand.
2. Sandy, salt-bearing clay.
3. Sand with sub-fossil shells.
4. Corals.
5. Water-bearing sand.

From bed No. 3 the following shells and echinids were obtained:—

Laganum Sinaiticum, Fraas.
Clypeaster placunarius, Agassiz.
Lucina lingua bovis, Forsk.
Anomalocardia holoserica, Reeves.
Cerithidea palustre, Jousseaume.
Asaphis violacens, Forsk.
Dosinia amphidesmoides, Reeves.
Trachycardium peregrinum, Jousseaume.

As all these shells are living in the Red Sea at the present day, the age of these beds must be late Pleistocene to Recent.

The northern half of the plain.—On the east side, to the north of Wadi Shiddiq, the plain from this point to the mouth of Wadi Geba is covered with granite, dolerite, and quartz-felsite boulders mixed with blown sand. Opposite the mouth of Wadi Meâr large mounds of these boulders are piled up, but they gradually thin out towards the middle of the plain where flint and limestone gravel take their place.

On the west, between El Tor and Gebel Saidna Musa, the ground is covered by a salty clay or sand over which are dotted many little mounds of sandy clay on which grows the shrub "ghargad." Between Tor and El Wadi a saliferous clay occupies the low flat ground, which in winter is a marsh.

Gebel Abu Suwera.

Along the seaward foot of this hill is laid a bank of gravel, etc., 15 to 30 metres thick, which is evidently of Pleistocene age, and is probably the continuation of the younger beach which runs along the foot of Gebel Hammam Musa, and which is described by Walther.

Top.

Pure Coral Reef.....	3·5 m.
2. Fine breccia, in places covered by *Balanus*, echinid spines, *Ostrea* and coral fragments	1·5 m.
3. Base of coarse angular blocks of granitic material forming breccia containing blocks of sandstone, etc..	1 m.
	6 m.

Opposite the mouth of Wadi Hebran, but on the Araba side of the plain, small mounds appear near the foot of the ridge consisting of thin yellow sandstones,* limestones, and marls containing *Turritella*, etc. These, with others shortly to be mentioned, are evidently the shallow water deposits which were laid down unconformably on the limestone which forms the flanks of Araba, after the rise of the land had set in. The dip in the range is 12°, but gradually falls to 5° out in the plain, where the marls disappear under the gravels.

Along the edge of the limestone plateau on the east nothing but mounds of flint, limestone, gravel and boulders are met with for some time, until the mouth of Wadi Themâm is reached. From this point there begins a series of mounds of gravel and marl which gradually occupy the plain. These show a great resemblance in appearance to the deposits in the Nile Valley, and have evidently been laid down under similar conditions.

It is remarkable that while in all the wadis to the south of Shiddiq, masses of sand-rock and gravel are found perched on their sides even up to the watershed, in the valleys to the north these are conspicuous by their absence. What the explanation is, is not at all clear, but the most likely solution of the problem is that a subsidence of the land must have taken place south of that point, sufficient to cover the hills, and that during that time the various valleys were silted up, the water again recutting its way through this silt and leaving patches sticking high up the sides of the valleys. These may possibly belong to the same period as the lake deposits to be described later in Wadis Ferân, El Sheikh and Solâf, which are known to be of freshwater origin, but search has hitherto failed to reveal any fossil in the former.

From what has been seen at various parts of Qâ it seems fairly certain that it is composed of the limestone which crops out here and there, although at present it is covered up by blown sand and downwash. At several places on the coast a hard limestone was seen to form the floor of the sea, and this passed away underneath the salty sand and clay which occupy the edge of the beach.

Although there is no direct proof in the lower part of the plain of its having been let down by a fault from a higher position, higher up there is, as will be shown later on.

Younger Pebble Beds.

These occur along the sides of Wadi Ferân and overlie those just described. They consist almost entirely of igneous pebbles, and the plain at the mouth of the above-mentioned wadi is also covered with them.

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* See Section I.

In this valley these gravels and conglomerates occupy its sides and bed for over 6 kilometres. They cap the low hills of gypseous marl which form the north side of the wadi, while the wide plain between this and the sea, as well as that of El Markhâ,* are also covered with these beds and blown sand. Wadi Sidri.

Seven and a half kilometres to the south of this valley there begins a deposit of gravel and conglomerate which in the sides of the wadi is seen to overlie a bed of white calcareous sandstone lying on the gypsumised beds to the east. From Wadi Wardân it sends off a long tongue to the north-west which lies on the gypsum the whole way until it ends against the (?) Pliocene of Gebel Raha, a distance of 11·5 kilometres. Wadi Wardân

To the west and north this deposit occupies the plain up to Ayun Musa, where it is replaced by the recent beach, but to the east of these springs it extends on to the Isthmus of Suez with the deposits of which it is continuous.

From the point where the above-mentioned tongue ends the (?) Pliocene forms a low plateau sloping west which is cut up by numerous wadis into long narrow tongue-like pieces on the ends of which the Pleistocene gravels are laid. This plateau continues for about 15 kilometres, when the Pleistocene sweeps round suddenly to the east and takes its place in a slightly lower plateau which occupies the ground from this point (the Wadi Kahali) from the cliff of El Raha on the east to the sea, and north on to the Isthmus of Suez. Here it consists mainly of sandy clay with some gypsum covered by flint conglomerate and gravel, and forming a plateau 15 to 20 kilometres wide from east to west.

Further to the west near the mouth of this wadi, patches of Beach Limestone occurred containing many pectens in a brittle state, as well as many bryozoa. Above this came a dark-green or brown clay full of salt which forms a crust on the surface. Thin beds of conglomerate formed the surface in the majority of places, while the clay formed a low plateau which extends up to Ayun Musa. Wadi Dehesi.

Round these springs there is a recent beach lying 15 to 20 metres above the sea. Some of the springs occur in low cones with a basin in the centre, which have evidently been formed by the water cementing the loose sand together by depositing the calcareous matter which it has in solution, as freshwater shells such as *Melania* were seen embedded in them. To the east of the wells was a bank of oysters which had not yet lost their colour, while numerous pieces of broken shells such as are seen on the coast were also observed in the sand. Ayun Musa.

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* See Section VI.

To the east and north the greenish saliferous clay formed a low plateau capped by a bed of gravel and boulders which bent away to the north-east about half-way between the wells and the Suez Canal. On the shore-plain were many limestone boulders, while nearer the sea, and on the banks of the Canal, were recent marine beds full of shells, forming a raised beach which is evidently continuous with that between Suez and Gebel Ataqa.

Freshwater lake deposits.

These occur at four places:

1. Wadi Gharbi.
2. „ el Sheikh.
3. „ Ferân.
4. Foot of Gebel Hadûd.

1. *Wadi Gharbi.*—These deposits, consisting of bedded sandy clay and boulders, occur on either side near the Naqb el Hawa, and have the appearance of having been laid down in a lake. The presence of well-grown palms, tarfa and seyal at this spot is proof of good soil as well as water in the bed of the wadi.

2. *Wadi el Sheikh.*—From the mouth of Wadi Qassab to El Watîa on either side, and in the mouths of its tributaries, masses of bedded sand, marl, and in some places marly limestone, are found lying from valley level up to about 30 metres above it, and their surface seems to be more or less horizontal, as it is highest above the valley lower down the wadi. In these occur small *Physa* or immature *Lymnæa* in abundance, and a mammalian tooth was also obtained from them. Towards El Watîa these deposits spread on the one side to the plain of Elwi el Agramia, and on the other to the low ground at the foot of Gebel el Gharbi. In the wadi, a grove of tarfa with trunks of great thickness attests the presence of excellent soil in its bed, and this disappears with the marly deposits. Further down, a little below where the road from Suez to the Convent crosses the valley, these deposits again appear, containing shells and numerous remains of the roots of water-plants. This ceases about 2 kilometres above its junction with Wadi Solâf.

3. *Wadi Fêran.*—About a kilometre above the entrance of Wadi el Akhdar these deposits again appear and continue to the end of the

FRESHWATER LAKE DEPOSITS OF WADI EL SHEIKH.

marsh at the foot of the Oasis of Ferân, a distance of 7·5 kilometres. At first they are not much above valley level, but rise to 30 metres above it where the palm grove begins, being continuous with the bed of the wadi. On its western end there is no corresponding fall in level, and this can only be explained by supposing that the rock which stands in the middle of the valley was continuous with the sides and acted as the barrier to form the lake, it becoming breached eventually and the water gradually drained off.

A grove of tarfa and palms marks the site of this old lake, as it did in that of Wadi El Sheikh.

4. *Foot of Gebel Hadûd.*—In a hollow at the foot of Gebel Hadûd there occurs a small patch of sandy clay about 30 metres thick similar to that above described, through which the small wadis have cut their beds, thus proving that it existed before the drainage had been formed.

Walther had satisfied himself as to the freshwater origin of these marls during his journey in Sinai in 1887. No other explanation than their deposition in lakes formed by an interruption of the drainage seems to the author sufficient or capable of accounting properly for all observed facts.

POST-TERTIARY FOSSILS OF WESTERN SINAI,

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

Post-Pliocene.

Qrum and El Tor.

Haliotis cruenta, Reeve.
Capiluna Ruppelli, (G. B. Sowerby).
do. *do.* *var. Barroni*, (R. B. Newton).
Emarginula incisura, A. Adams.
Scutum unguis, Linn.
Clanculus pharaonicus, Linn.
Stomatella sp.
Turbo radiatus, Gmelin.
Nerita (*crassilabrum*, E. A. Smith)=*Albicilla*, Linn.
Hipponyx subrufus, Lam.
Cypraea erosa, Linn.
do. *turdus*, Lam.

Qrum and El Tor—(*continued*).

Natica (Mammilla) melanostoma, Gmelin.
Cerithium caeruleum, G. B. Sowerby.
do. *Ruppelli*, Philippi.
do. *erythræonense*, Lam. (=*tuberosum* Reeve).
Vertagus cedonulli, G. B. Sowerby.
Pirenella mammillata, Risso.
Triforis perlatus, Issel.
do. sp.
Vermetus, sp.
Strombus fasciatus, Born.
do. *tricornis*, Lam.
Canarium dentatum, (Linn) var. *erythrinum*, (Chemn).
do. *gibberulum*, Linn.
Lampusia vilearis, Lam.
Fasciolaria polygonoides, Lam.
Melongena paradisiaca, Reeve.
Vasum cornigerum, Lam.
Mitra aureolata, Swainson.
Columbella flava, Bruguière.
Nassa pulla, Linn.
do. *(Alectron) glans*, Linn.
Murex ternispina, Lam.
Chicoreus anguliferus, Lam.
Sistrum elatum, (Blainville).
Ricinula ricinus, Linn.
Oliva inflata, Lam.
Ancilla ovalis, (G. B. Sowerby)=young of *A. cinnamomea*, Lam.
Terebra consobrina, Deshayes.
do. *duplicata*, Linn.
do. sp.
Conus arenatus, Lam.
do. *erythræensis*, Beck.
do. sp.
Bulla ampulla, Linn.
Dentalium octagonum, Lam.
Arca imbricata, Bruguière.
do. *squamosa*, Lam.
do. sp. (2 forms).
Anadara radiata, (Reeve).
Barbatia lima, (Reeve).
Limopsis cf. *sordidus*, Tate.
Septifer bilocularis, Linn.
do. *excisus*, Wiegmann.
Spondylus aculeatus, Chemn.
Lima cf. *squamosa*, Lam.
Plicatula ramosa, Lam.
Cardita calyculata, Linn.

Qrum and El Tor—(*continued*).

Codakia exasperata, Reeve.
do. *Fischeriana*, Issel.
do. *fibula*, Reeve.
Divaricella ornata, Reeve.
Arcopagia scobinata, Linn.
Chione costellifera, Adams and Reeve.
Circe corrugata, Chemn.
do. *pectinata*, Linn.
Tapes virginea, Linn.
Chama Jukesi, Reeve.
do. *nivalis*, Reeve.
Orbicella Forskaliana, Ed. and H.=(*O. mammilosa*, Klunzinger).
Cyphastræa chalcidicum, Forsk.
Prionastræa, sp.
Goniastræa favus, Forsk.
Metastræa Ægyptorum, Ed. and H.
Fungia patella, Ellis and Solander, var. *lobulata*, Klunzinger.
Porites cf. *incrustans*, Defr.

West side of Ras Mohammed and plain between Ras Mohammed and El Tor.

Capiluna Ruppelli, (G. B. Sowerby) var. *Barroni*, R. B. Newton.
Cerithium erythræonense, Lam. (=*tuberosum*, Reeve).
Vertagus cedonulli, G. B. Sowerby.
Strombus tricornis, Lam.
Dolium pomum.
Oliva inflata, Lam.
Terebra consobrina, Deshayes.
Conus monachus, Linn.
Dentalium octagonum, Lam.
Arca imbricata, Bruguière.
Anadara sp.
Barbatia lima, Reeve.
Glycymeris pectunculus, Linn.
Margaritifera vulgaris, Schumacher.
Ostrea upper valve indet.
Cardita angisulcata, Reeve.
do. *calyculata*, Linn.
Codakia exasperata, Reeve.
Arcopagia scobinata, Linn.
Cardium leucostoma, Born.
do. cf. *maculosum*.
Chama nivalis, Reeve.
Clypeaster placunarius, Agassiz.

Orbicella Forskaliana, Ed. and H.
Prionastræa sp.
Goniastræa favus, Forsk.
Galaxea irregularis, Ed. and H.
Cœloria Arabica, Klunzinger.
Porites cf. *incrustans*, Defr.

Section II.—PLIOCENE AND MIOCENE.

Pliocene.

The presence of beds of undoubted Pliocene age on the west side of the Peninsula of Sinai, has hitherto been unknown to geologists. Even now, although the beds about to be described cannot be said to be entirely Pliocene, they, as shown by the fossils, constitute passage-beds between the middle Miocene and Pliocene. In determining some fossils which were sent to him recently, Dr. Blanckenhorn, of Berlin, pointed out that certain of them had Mediterranean characters and indicated a Pliocene age, while others associated with them were of Miocene age.

The following are the fossils from Wadi Amara which were named:—

Clypeaster n. sp. aff. *subplacunarius*, Fuchs.
Pecten cristatus, Bronn.
Pecten revolutus, Mich.
Pecten scabrellus, Lam.=*(Sarmenticius.* Goldf.)
extends from Tortonian to Pliocene.
Pecten cf. *opercularis.*
Pecten Barroni, n. sp. Blanck.
Pecten revolutus, Mich.
Pecten. Schweinfurthi, Blanck.

The following fossils also come from Gebel Zieti, which is near Wadi Amara:—

Lucina sp. aff. *incrassata*, Dub.
Lucina div. sp.
Lucina columbella, Lam.
Corbula, sp.
Arca sp.
Cardium sp.

Corbula revoluta, Brocch.
Lithodomus, sp. n. ?
Lithodomus (*Botula*) cf. *cinnamonea*, Lam.
Cyprœa sp.
Natica redempta, Mich.

Of these fossils Blanckenhorn writes as follows:—

"It is to be assumed that *Lithodomus* (*Botula*), *cinnamomea*, *Gastrochœna Retzi*, oysters of the *crassissima-gingensis* group, *Lucina* sp. aff. *tigrina* and corals like *Cyphastrœa chalcidicum*, etc., persisted from Miocene to Pleistocene times in the Erythræan region in a salt "Binnensee" situated somewhere in the deepest part of the Gulf of Suez. In the Upper Pliocene there was the second invasion of the Mediterranean forms into the Erythræan region. At this point there came in *Pecten varius*, *Pecten benedictus*, *Cerithium conicum*, *Ostrea cucullata* and *Plicatula*, *Arca lactea*, etc.

"Possibly in the neighbourhood of Sinai there may be a place which still contains remains of this more continental transition period between the Middle Miocene (Helvetian) and the Upper Pliocene."

The deposit at Wadi Amara consists of:—

Top.—Limestone riddled with borings now filled with calcareous matter.

Below this came a yellowish sandy limestone containing gypsum and some veins of celestine while there were also numerous teeth of *Carcharodon megalodon* Ag., *pectens* and *echinids*. This rested on gypsum, as did the deposit on Gebel Zieti which is of a similar nature to that at Amara.

There are suggestions of the same order of things in the list of fossils recently determined by R. B. Newton, Natural History Museum, London, from Wadi Ethal, and Gebel Khadêd el Dhib. At Wadi Ethal there is a series of gravelly beds lying at the foot of the Usêt-Hammâm Farûn range, which contain many *Ostrea* and broken pectens. The former fossil has been determined as *Ostrea* cf. *undata*, which is a Mediterranean form, and is known from the Pliocene of Italy.

At the other place—Gebel Khadêd el Dhib—the following fossils have been determined by R. B. Newton and Dr. Blanckenhorn:—*Ostrea* cf. *undata*, *Pecten scabrellus* (?), Brocchi, *Pecten Josslingi* (?), G. B. Sow. and *Pecten* sp.; *Pecten Kochi*, Loc. = (*Pecten Fraasi*, Fuchs), *Pecten sub-Malvinæ*, Blanck., spines and plate of *Cidaris avenionensis*, Desm. Here again there is the suggestion of the admixture of 2nd and 3rd Mediterranean forms.

To the north of Wadi Wardan is a small group of hills consisting of re-made rock composed of pieces of limestone, marl and sandstone, all mixed indiscriminately, and further to the north covered by gravel, while their base is a calcareous sandstone resting on gypsum.

Between this patch and the cliff of El Ti there extends a low plateau which consists of gritty limestone at the top, calcareous sandstone in the middle, and gypseous marls resting on the gypsum bed. To the south this is seen to have a dip of 10° W., but further north the dip decreases to 3°. The plateau slopes upward and merges into Gebel el Ti, no cliff marking the boundary between the Eocene and this deposit. At the top is a more calcareous bed which may possibly contain foraminifera, while overlying this is a bed of rounded pebbles of a nummulitic rock and limestone boulders. This plateau covers an area of perhaps 15 by 4 kilometres, and further to the north is replaced by the Pleistocene clays and gravels.

These beds occupy the same position with regard to the gypsum as the Miocene or passage beds between the Upper Pliocene and Middle Miocene. Might they not represent the more continental transition period referred to by Blanckenhorn in the above-quoted remarks ?.

Miocene.

Rocks of this age have been known to exist in Sinai for some time. In 1868, Bauerman,* in a visit to Western Sinai for the purpose of examining the district for its old mines and ore deposits, described deposits from near the mouth of Wadi Gharandel, Wadi Tayiba, and Gebel Sarbût el Gamel, which he characterised as "Flint-Conglomerate with Corals." He also noted these beds in Gebel Abu Alaqa, and on either side of Wadi Sidri, where he describes them as being an alternation of flint-shingle with thin coral limestones and beds containing a coarsely ribbed *Pecten*. These he determined as Miocene.

In 1882 M. Raboisson † stated that he found Middle Miocene beds at Wadi Hawara and Gharandel from which he obtained *Ostrea Boblayei*, Deshayes.

In 1893 Rothpletz‡ described Miocene from Wadi Ethal northwards, the fauna of which he describes as North African.

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* Q. J. G. S. 1869, p. 23, et seq.

† "Contrib. à l'histoire Stratig. de la Pénins. Sinaïtique," etc., 1883. Journal de l'Académie des Sciences de Paris, tome XCIV.

‡ "Stratigraphische von der Sinaihalbinsel"; Neues Jahrb. Miner. etc., 1893, Bd. I., pp. 101-104.

Miocene rocks can be shown to have a much greater extension in Western Sinai than was previously known before the present survey was made. They have been recognised all over the sedimentary area from the north side of Wadi Wardan to Gebêle, a small village south of the quarantine station at El Tor.

Beginning at the most southerly extension of the Miocene and going northward, the first deposit to be described is that outcropping near Gebêle.

Behind this village is a low escarpment which might have been the coastal scarp, and is covered with sand. It is composed of limestone weathering in a nodular manner and containing much salt and a bed of *Ostrea Virleti*. This disappears to the east and north under the sand and downwash from the hills, but evidently crops up again in some low knolls exposed to the east of El Tor,* where the same oysters were again found, but, in addition, pieces of a flat echinoderm like *Scutella*, pectens, cardia and a few gastropoda were associated with them. Above this limestone came a bed of consolidated grit, unconformable to it, and then igneous gravel and sand. Here the beds seemed to dip sharply seawards. This limestone is exposed all the way round to El Wadi, the sides and floor of which it forms, and then it runs on to the flanks of Gebel Saidna Musa, being evidently of the same age as the bed capping that hill.

El Saidna Musa and El Araba range, etc.—The first of these hills consists of Nubian sandstone and Cretaceous marls, capped by a bed of crystalline limestone containing corals in very poor preservation. At its base and stretching a little distance inland is a raised beach laid on against the sandstone, while about half-way up the side of the hill occurs another. The following is the general sequence seen:—

Top.

1. Hard limestone dolomitised to a certain extent, containing corals from which all the septae have been dissolved. Its top is 233 metres above the sea. Dip 5° S.E. †
2. Pebble beds mixed with grit and containing fragments of shells.
3. Gritty rock with calcareous cement.
4. Yellow calcareous sandstone covered by a recent beach.

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* See list of fossils at the end of chapter on Miocene.

† According to Walther this reef is a dolomite containing 40% of $MgCO_3$, and is of Pliocene age, but the evidence is all in favour of its being Miocene, as the beds to the north (of which it undoubtedly is an isolated part) are certainly Miocene, while those occurring in the plain and extending on to the flanks of Gebel Hammam Musa, have also been found to contain Miocene fossils. The probabilities are thus all in favour of a Miocene age being assigned to these beds. Further, no certain Pliocene beds have been met with in this region.

Hot springs: their origin.—At the foot of this hill issue several warm springs much resorted to by the Bedawin and the people of El Tor. The origin of these springs seems to be a line of fault running along the foot of the hill, up which the water from the plain of Qa, after sinking down through the porous beds which compose it, is forced by the hard face of the rock which has been let down. The appearance of the hill is in favour of the fault theory, as it ends in a more or less vertical face on a flat plain.

Abu Suwêra.—This bed of coral limestone caps the ridge from Saidna Musa to where Wadi Abu Suwêra has breached it, and is continued on the top of Gebel Abu Suwêra along to where Wadi el Araba cuts its way through it. At the foot of this hill is a small beach of crystalline limestone containing corals, which is about 13 metres thick. This is evidently part of the reef which has been faulted down from the hill top. The reef on the top of Abu Suwêra was in the same state of bad preservation as that on Saidna Musa, all the corals being much altered.

Gebel el Araba and Qabeliat.—Under these names are known the parallel ranges which extend from Gebel Naqûs to the Wadi Ferân, a distance of 54 or 55 kilometres.

Along the eastern and highest ridge from the mouth of the small drainage which comes down from the internal ranges opposite Naqûs there is a deposit of Miocene limestone and conglomerate on the side facing El Qa, which extends right up to Ferân. At its southern end it is covered largely with downwash, but as it is followed north it gradually crops out more and more, encroaching further up the dip slope of the ridge until it covers it entirely, forming the top of the escarpment. It overlies Cretaceous beds at the south end, but about a third of the distance northwards, Eocene beds in the form of *Nummulites Gizehensis* limestone, make their appearance under it, and continue up to Ferân.

Unconformity.—Between these older beds and this Miocene deposit there is a strong unconformity,* marked by a bed of conglomerate which, where the Eocene beds occur, is made up of rolled pebbles of *Nummulites Gizehensis* limestone, and where the dips of the two series of beds could be measured, that of the older was 22°, the

* See Section I.

younger was 15°, to the east. It thus follows that as the dip-slope of the ridge was climbed, younger beds were observed near the plain, while at the top the older representatives were found forming the scarp.

Faulting.—About 30 kilometres from the southern end the beds are much broken and displaced by a combination of strike and dip-faults, by which the whole of the beds, including the younger, are broken into a series of secondary ridges† and shifted about 4 kilometres to the west, the younger beds capping the ridges in the vicinity of the fault. In addition the Miocene beds are broken by a strike-fault on either side of the Wadi Qabeliat, by which a secondary ridge enclosing a plain is formed to the east of the main escarpment.

The secondary ridges* on the west side of the range, as has been stated previously, have been formed by a series of strike-faults, the throws of which have been determined, that of the most easterly is 104 metres, while the most westerly is 79 metres below it. In the western ridge there are the remains of a syncline, with its axis lying west of north and south of east, with dips towards the centre of 8° and 10° respectively. These observations prove that the age of these earth movements in question is Post-Miocene, probably Pliocene.

These Miocene deposits consist mainly of hard, more or less crystalline limestone, unconformably overlaid by the shallow-water representatives which were noticed in the plain of El Qâ earlier in this report.

The following is their sequence as made out from various exposures :-

Top.

1. A pecten bed † containing a flat echinid like *Scutella*, a few corals and a strongly beaked oyster. This ran under the white, sandy bed mentioned in the description of El Qâ.
2. Limestone full of pectens, etc., *Ostrea Virleti* near top.
3. Impure limestone in which pebbles of flint become very common. This contains a bed of *Ostrea Virleti.*
4. Hard brownish or grayish limestone containing a few corals in bad preservation.
5. A conglomerate of pebbles of flinty or nummulitic limestone.

On account of the scattered nature of the various beds, and of their never occurring together in the same escarpment, it is extremely difficult to obtain anything but an approximate thickness for them, but

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* See Section I.

† See list of fossils at the end of the chapter.

there are at least 61 metres of them lying on the flanks of the main ridges of Araba, and they are about 488 metres above sea-level.

Qabeliat.—On the top of this escarpment there is a bed of these deposits 9 metres thick. This slopes down towards Wadi Ferân where the following section was obtained:—

Top.

1.	Crystalline limestone containing small echinids and a thin layer of *Ostrea Virleti*	9 metres
2.	Limestone with echinid spines	3 „
3.	Limestone containing *Heterostegina depressa*, d'Orb... ...	3 „
4.	Limestone containing a thick-shelled oyster like that found in El Araba, and large pectens	3 „
		18 metres

The whole were dipping 8° to the east.

Limestone plateau east of El Qâ.—On this plateau occur outliers of Miocene deposits at three places, i.e., Gebel Asfar, the sides of Wadi Abura and Gebel Rigma and Wagraf. The first and last occupy the highest points of the plateau.

Gebel Asfar.—This hill, composed as it is almost entirely of Miocene deposits, seems to have been deposited in a syncline formed of Eocene and Cretaceous rocks, for although the opposite side of the basin is now removed, evidence is forthcoming of its existence higher up the Wadi Abura. On the remaining side it dips 30° to the north-east. The following is the sequence of these beds from above:—

Top.

1. Mass of calcareous sandstone.
2. *Heterostegina* bed with bits of *Pecten*,* etc.
3. Calcareous grits containing coral.
4. An alternation of sandy and gritty beds with conglomerate.
5. Conglomerate of flints, flinty limestone and nummulitic limestone pebbles.

These beds dip at an angle of 5 degrees E. 5° S. It was impossible to measure the thickness of the different beds, because they formed steep precipices where well exposed, and where examined

* See list of fossils at end of chapter.

were covered with debris. On the sides of Wadi Abura deposits of the same brown colour and pebbly, gritty nature also occur.

Gebel el Rigma. *—The beds here are again laid down in a sharp syncline of nummulitic limestone, and consist of similar sediments to those in Gebel Asfar. The following is the succession:—

Top.

1. Conglomerate of rounded flint pebbles, lying 850 metres above the sea.
2. Thick beds of gritty limestone alternating with conglomerate, and containing at the base corals and oysters.
3. Conglomerate of nummulitic limestone pebbles, containing a thin bed of gritty limestone in which occur pieces of an echinid (*Scutella*).

These outliers are evidently the remains of a much larger deposit which has been removed, the isolated patches owing their existence to their position. That they are older than the fault which separates the sedimentary area from the igneous ranges is undoubted, since the base of the deposits at Gebel Asfar has been let down below ground at the mouth of Wadi Geba.

Wadi Khadahid.—Near the mouth of this wadi the plain deposits are seen to be composed of marly beds lying on a calcareous sandstone, which is laid on the edge of nummulitic limestone containing *Nummulites Gizehensis.* The following is the sequence from above:—

Top.

1. Marl with veins of gypsum.
2. Clay.
3. Fine sandstone.
4. Gritty calcareous sandstone containing pectens.

The basal beds are tilted at an angle of 30° and rest on those of the nummulitic limestone, which dip 60° to the west. This seems to prove that the earth-movements were later than these beds, and it is very probable that when the fossils from them and the patches which rest on the top of the limestone hills to the east be examined, they will be shown to belong to the same deposit and that the former have reached their present lowly position through being let down by a fault. In the gravels which overlie the marls, igneous boulders occur, they having evidently come down Wadi Ferân at a later date.

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* See Section II.

Gebel Ekmi.—On the west side of the camel-path leading to Wadi Ferân there is a different series of beds to those described above. The following is their sequence :—

Top.

1. Crystalline limestone containing corals 299 metres above the sea.
2. Sandstone.
3. A thin conglomerate.
4. Sandstone.

Borings of *pholadidæ* and pieces of shell like *Tridacna* are to be seen on the weathered surface. Here the beds were dipping from 10° to 12° to the west.

A little to the north of Gebel Ekmi, on the side of Wadi Ferân, these beds, dipping at 15°, rest on what appears to be Nubian sandstone, dipping 40° W. :—

Top.

1. A mass of conglomerate of flints and pebbles of nummulitic limestone.
2. Yellowish marls.
3. Calcareous limestone containing many oysters.
4. Thin limestone with coral.
5. (?) Nubian sandstone.

These beds extend right across the plain to Qabeliat, at the foot of which coral-bearing limestone lies on gypsum.

North of Wadi Ferân.—The deposits described to the south of this wadi are evidently continued to the north, and have their deep-water representatives in the large mass of fairly pure limestone which forms the low plateau between Wadi Withr and the ridge connecting Gebels Abu Alaqa and Mokateb. This plateau measures 19 kilometres average length, and 10 kilometres in width. Taking the exposures examined on the side of Ferân in their order from east to west, the following are the sections seen :—

Wadi Khrêza.

Top.

1. Calcareous beds containing *Ostrea Virleti*, Desh., pectens, etc.
2. Sandy limestone full of flat echinids *Amphiope* cf. *palpebrata*, Pomel.

These rest on the nummulitic limestone which here dips at 32° W., and in turn pass under the greenish marly beds mentioned in the description of El Qâ.

Gebel Withr.—In this section * upper beds are present:—

Top.

1. Calcareous grit and sand containing corals, casts of pelecypoda and gastropoda, all badly preserved.
2. More calcareous beds with grit.
3. Greenish marls, reddish at the base, the whole deposit being 70 to 80 metres thick. These form the limb of a syncline, of which the previous section composed the other, the limestone having been removed in the latter.

In the Gebel Withr section, gypsum and gypseous marls, which were found to be altered Cretaceous beds, underlie the Miocene deposits. In the Miocene plateau the beds are mainly yellowish limestone containing sandgrains.

Between Gebel Khadêd el Dhib and Withr.—Near the mouth of Wadi Ferân, where a hill of nummulitic limestone forms its northern edge, there is a "Beach deposit" let down in a faulted syncline, which is evidently part of the deposits further to the east. It consists of the following beds:—

Top.

1. Conglomerate of limestone pebbles.
2. Gravel containing rolled nummulites.
3. Ochreous, calcareous grit with echinid spines, pectens, etc.†
4. A basal marly bed.

These beds dip 15° E., and on the edge of the fault 30° W., while the underlying nummulite beds dip 30° E.

Returning to the east side of the plateau, after leaving Wadi Ferân, the basal beds are not seen, as they have been let down by a fault against the Cretaceous marls. This fracture is continued along the foot of Gebel Abu Alaqa‡ which next falls to be described.

Gebel Abu Alaqa.—This hill is composed of Nubian sandstone at the base with some Cretaceous marls overlying it, above which come the Miocene deposits which are the same as those in Gebel Wagraf and Asfar, and are bent up into a small syncline.

On the west side of the fault the beds dip 27° W., while on the north side of the syncline (whose axis is east and west) the dip is 22° S., and on the opposite side it is only 5°.

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* See Section II.

† See list of fossils at end of chapter.

‡ See Section III.

Wadi Sidri.—Passing down this wadi the sequence of the area can be fairly well seen :—

Top.

1. Fairly pure limestone which forms the main mass of the plateau.
2. Flint conglomerate (subangular) cemented by lime. (This is probably a reconstructed limestone).
3. Loose sandy and gritty beds.

There is a dip of 25° to the south-west on the edge of the area near the mouth of Wadi Budra, and current-bedding is well seen in the sandstones. There is also a slight dip eastward from Gebel Withr, but a more pronounced one to the south. There is evidently a roll north and south towards Wadi Sidri and Ferân.

From the beds seen in the eastern half of this deposit it would seem that the shore of the sea in which they were laid down was not far distant, and that the water deepened fairly rapidly to the west, the conglomerates which are a conspicuous feature in the eastern deposits not being met with on the west. Wherever the base of the Miocene is visible on the west it is seen to rest on a floor of gypsum and gypseous marl which stops short at a fault along Wadi Withr, the latter having thrown down the unaltered limestone against it ; the fracture is therefore subsequent to the overlying newer beds.

Sêh Baba.—To the north of this Wadi a small hill has yielded Eocene foraminifera of Libyan age, and this series has some things in common with it, although there are other features incompatible with its determination as Lybian, viz., the presence in it of pebbles of limestone containing *Nummulites Gizehensis.* The final determination of its age must await the description of the fossils collected from it. The following is the sequence observed in it:—

Top.

1. Crystalline beds with various fossils. *
2. Limestone with large oysters.
3. Foraminiferal limestone.
4. Limestone with derived flints.
5. Marls.
6. False-bedded sandy limestone.
7. Gypseous marls with pectens, (?) *echinolampas*, etc.
8. Marls which weather in a spheroidal manner.
9. Marl beds with gypsum.
10. Conglomerate of flints and pebbles of limestone, among which were some containing *Nummulites Gizehensis.* Some rolled fossils, apparently derived, are also present.
11. Gypseous clays.

* See list of fossils at end of chapter.

This deposit* lies in a hollow between Cretaceous limestones and marls. On the east it dips 20° west while the underlying Cretaceous marls are inclined 63° in the same direction. On its western edge the Cretaceous limestone is almost horizontal, and against its broken ends rests this younger deposit at an angle of 5°.

Another patch, evidently of the same nature, was seen in a hollow lying on Cretaceous marls about 2 kilometres west of El Markhâ, against which the Cretaceous limestone is let down by a fault.

Sarbût el Gemel.†—This is the next place where beds of Miocene deposits occur. This hill occurs on the north side of Wadi Hamr in the angle formed by its junction with Wadi Ibn Sakkar and occupies the downthrow side of the main fault which has let down the younger beds to the west. The Miocene beds rest in a syncline of Cretaceous limestone dipping at 40° to the west, but with a much smaller angle of dip to the east. The following is a section of the beds :—

Top.

1. Conglomerate of sub-angular and rounded flints cemented by calcareous sandy matter.
2. Boulder conglomerate of Cretaceous limestone and flint.
3. Limestone and flint pebbles.
4. Beds of conglomerate.
5. Marly limestone.

A few pectens were obtained, and the thick-shelled oyster which occurs in the other deposits was also seen, as well as a few badly-preserved corals.

There is an extension of this deposit on the south of the wadi, and patches also occur along the flanks of Gebel Abu Demat as far as Wadi Ethâl, down the sides of which occur some deposits of the same age.

Wadi Tayiba.—At the mouth of Wadi Tayiba‡ there occurs a series of tilted beds with a bed of andesitic basalt, which apparently lies concordant with the beds above and below it. Blanckenhorn§ gives the following section of these beds, with which the writer agrees, the

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* See Section VI.

† See Section V. Also see list of fossils at end of Chapter.

‡ See Section V. Also see list of fossils at end of chapter.

§ "Das Miocan" ; Zeitschr. d. Deutsch. geol. Gesell., 1901, Heft I, Band 53, S 77.

former regarding them as belonging to the Lower and Middle Miocene :–

Top.

1. Greenish, brittle sandstone with marl and gypsum ...	15	metres
2. Flint conglomerate with small fragments of black flint and few rolled nummulites, alternating with greenish, finely-laminated, marly sandstone streaked with gypsum. Shells of *Ostrea* sp.. *Pecten cristato-cristatus*, and *P.* sp.	20	„
3. Green, brittle, nodular, marly clay flecked with manganese	0.6	„
4. Mottled marly sandstone	0.5	„
5. Coarse conglomerate	0.5	„
6. Dark melaphyre-basalt with green zeolites passing into brown-red tuff	10.0	„
7. Black, finely granular sandstone which appears altered by contact with the basalt..	1.2	„
8. Grey sandstone	0.5	„
9. Breccia of reddish and grey nummulitic limestone fragments	1.0	„
Total	49.3	metres
Under these Blanckenhorn found red laminated marly limestone with small *Nummulites*, cf. *variolaria*, etc...	10.0	metres

This the writer did not see, and accordingly mapped all the limestones below as belonging to the Senonian.

With the determination of the age of the beds underlying the basalt, the writer does not agree, and regards them as the extension of the Oligocene which occurs to the west of the Gulf of Suez.

In the middle of Wadi Ethal * is found 10 metres of sometimes soft, sometimes hard, marly sandstone and limestone with veins of gypsum, which dips 28° N.W., and contains the following fossils :—

Rolled nummulites.
Numerous shells of *Pecten cristatocostatus*, Sacco, var. *Newtoni*, Blanckenhorn.
Ostrea sp.
Ostrea Virleti, Desh.
and further on, *Ficula condita*, Brogn.
Neptunus granulatus, Milne-Edw.
Balanus sp.

* "Das Miocan," Zeitsch d. Deutsch. geol. Gesell., 1901, Heft 1, Band 53, s. 77.

Rothpletz also collected from the neighbourhood of Wadi Ethal and northwards the following fossils:—

Psammechinus dubius, Ag.
Spatangus ocellatus, Defr. = *Maretia Fuchsi*, Oppenh., according to Blanckenhorn.
Ostrea batillum, May.
Pecten Malvinæ, Fuchs.

To the west of Gebel Krêr is a second ridge, Gebel Gushia, consisting of a hard calcareous sandstone containing layers of flint pebbles, and in which *Ostrea Virleti*, Desh., were seen, beneath which came gypseous marls, the whole dipping west 3°. Further west, near the flanks of the Usêt-Hammam Farûn range, are beds* forming a syncline, with a dip towards the centre of 12°, and consisting of the following members:—

Top. Marly beds with gypsum.
Base. Sandy calcareous beds containing pectens and ostrea.

These beds may perhaps be the basal members of the Miocene, but it was impossible to verify this as they were covered up to the east, and the matter was further complicated by the gypsumisation of these rocks. As this was the apparent relationship it has been adopted, and the beds above-mentioned have been regarded as the same as the gypsumised rocks about to be described.†

On the north side of Wadi Gharandel in Gebel Hoshera there occurs a series of beds which are evidently a continuation of those of Gebel Gushia. In this hill the following beds were made out:—

Top.
1. Beach limestone containing nullipores, pieces of *Pecten*, and casts of *Conus*, etc.
2. Whitish marly limestone containing thick-shelled, ribbed oysters. (*Ostrea Virleti*, Desh., and *digitalina*, = var. *Rohlfsi*, Fuchs.)
3. Greyish marls with oysters and gasteropoda.

These rest unconformably on gypsumised beds, which are of Cenomanian age as determined by the fossils. Other two patches of similar rocks occur to the north of this, while on the continuation of the ridge two more good-sized areas of these beds were discovered later. Gebel Ziêti is capped by the same beds as those met with in Hoshera. In the plain of Amâra there occurs an area of shallow-water deposits, evidently lying in a syncline of the gypsum which here forms the

* See Section IV.

† Since writing the above, the ostrea found in these beds has been identified as *Ostrea* cf. *undata* which points to a higher horizon, viz.—a passage bed between Miocene and Pliocene.

floor. In a hill near the north edge of the plain and not far from the Suez road a different kind of deposit was met with. It consisted of: —

Top.

1. Limestone riddled with borings now filled with calcareous matter.
2. A yellowish sandy limestone containing gypsum, and here and there veins of celestine, while there also occurred numerous large shark's teeth, flat and heart-shaped echinids, nearly all broken, as well as numerous small specimens about the size of split peas. Numerous specimens of *pectinidae* and echinoderm spines were found.

Gebel Khalafa. This deposit rests on the gypsum, and extends away towards the sea, towards which deeper water conditions seem to have existed, as there is a fairly pure white limestone in the series containing casts of the corals which were seen in the other localities, as well as the pectens. Further to the north this deposit contains, in the uppermost beds seen in the plain, numerous thick-shelled oysters (*Ostrea Virleti* Desh).

Higher up Wadi Wardân another patch similar to that at Ziêti was found capping a hill of gypsum. The top consisted of hard Beach limestone similar to that on the west side of the Gulf of Suez, in which several specimens of coral occurred, while the base was of a sandy nature and contained marly beds in which a few oysters were found, the whole being 122 metres thick. This was evidently part of what was once a continuous ridge, but which has been broken up into isolated outliers such as Gebel Khalafâ, Ziêti, and Hosherâ. Further to the north-east there is another patch of the same rock also lying on gypsum which is evidently continuous with the other exposures to the south.

LIST OF MIOCENE FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

Wadi Amara and Gebel Amara.

Carcharodon megalodon, Agass.
Ostrea Virleti, Desh.
Pecten cristatus, Bronn.
Pecten revolutus, Mich.
Pecten scabrellus, Lam.
Pecten cf. *opercularis*.
Pecten Barroni, n. sp. Blanck.
Pecten Schweinfurthi. Blanck.
Schizaster sp.
Schizaster cf. *Parkinsoni*.
Clypeaster subplacunarius, Fuchs.
Echinocyamus cf. *Studeri*, Sism.

Gebel Zieti.

Lucina sp. aff. *incrassata*, Dub.
Lucina div. sp.
Lucina columbella, Lam.
Corbula sp.
Arca sp.
Cardium sp.
Corbula revoluta, Brocch.
Lithodomus n. sp. ?
Lithodomus (*Botula*) cf. *cinnamomea*, Lam.
Cyprœa sp.
Natica redempta, Mich.
Symphyllia sp.

Gebel Hoshera.

Carcharodon megalodon, Ag.
Ostrea digitalina var. *Rohlfsi*, Fuchs.
Ostrea sp.
Ostrea Virleti, Desh.

Seh Baba and Wadi Legam.

Ostrea digitalina, Eichw.
Pecten cristatocostatus, Sacco.
Gigantopecten latissimus, Brocch.
Pecten sp.
Pecten cristatus, Bronn.
Serpula spirulæa, Lam., (derived from Eocene).
Cœlopleurus ?

Gebel Sarbut el Gemal.

Ostrea sp.
Pecten Ziziniæ, Blanck.
Pecten revolutus, Mich.
Pecten sp.

Gebel Withr.

Ostrea Virleti, Desh.
Pecten Ziziniæ, Blanck.
Pecten sub-Malvinæ, Blanck.
Echinolampas amplus, Fuchs.

Gebel Khadêd el Dhib.

Ostrea cf. *undata*.
Pecten sp.
Pecten Kochi, Loc.=(*Pecten Fraasi*, Fuchs).
Pecten sub-Malvinæ, Blanck.
Pecten Josslingi ? G. B. Sow.
Pecten scabrellus ? Brocch.
Spines of *Cidaris Avenionensis*, Desm.
Cellepora sp.

North side of Wadi Ferân.

Ostrea digitalina var. *Rohlfsi*, Fuchs.
Ostrea Virleti, Desh.
Pecten Ziziniæ, Blanck.
Pectunculus sp.
Lucina sp. (of the group of *L. Tigrina*, *L.*).
Lucina sp.
Natica sp.
Amphiope cf. *palpebrata*, Pomel.
Symphyllia ? Cast.
Heliastræa ?
Orbicella sp.

South side of Wadi Ferân,

Ostrea frondosa, Serres, var. *caudata*, Münst.
Ostrea Virleti, Desh.
Pecten cf. *Beudanti*, Bast: not *P. Ziziniæ*, of Blanck.
Pecten revolutus, Mich.
Pecten sub-Malvinæ, Blanck.
Solenastræa turonensis, Mich.
Operculina complanata, Bast.
Lithothamnium sp.

Gebel el Rigma and Wagraf.

Ostrea Virleti, Desh.
Solenastræa turonensis, Mich,

Gebel el Araba and Qabeliat.

Ostrea digitalina, var. *Rohlfsi*, Fuchs.
Ostrea Virleti, Desh.
Ostrea sp.
Pecten revolutus, Mich.
Pecten Ziziniæ, Blanck.
Pecten cf. *Zitteli*, M.E.
Pecten gloriamaris, Dub., var. *longolaevis*, Sacco.
Pecten sub-Malvinæ, Blanck.
Pecten cristatocostatus, Sacco, var. *Newtoni*, Blanck.
Spondylus, sp.
Corbis sp.
Cellepora cf. *palmata*, Mich.
Solenastræa turonensis, Mich.
Heliastræa sp. nov ?
Orbicella Schweinfurthi, Felix sp.

Wadi Khadâhid.

Pecten cristatocostatus, Sacco, var. *Newtoni*, Blanck.
Pecten sub-Malvinæ, Blanck.
Pecten Ziziniæ, Blanck fragments.
Pecten Kochi, Loc.

Wadi Geba and Gebel Asfar.

Ostrea digitalina, var. *Rohlfsi*, Fuchs.
Orbicella Schweinfurthi, Felix sp.
Operculina complanata, Bast.

Limestone north-east of El Tor.

Glycimeris pilosus, Linn.
Glycimeris, probably sp. nov.
Volsella Brocchi, M. Eymar.
Ostrea Virleti, Desh. (S. E. of Gebêle).
Pecten cf. *opercularis*, Linn.
Diplodonta cf. *rotundata*, Montagu.
Divaricella cf. *ornata*, Agass.
Tellina sp.
Callista erycina, Linn.
Papillicardium papillosum, Poli.
Solecurtus cf. *strigilatus*, Linn.
Kuplus (*Septaria*) cf. *arenaria*, Lam.
Solenastræa turonensis, Mich.
Heliastræa sp.

Section III.—EOCENE.

This formation has perhaps been less noticed by previous visitors to the Peninsula of Sinai than the Cretaceous, many of the rocks put down to the latter belonging in reality to it. Thus, in the map published by the Ordnance Survey of Sinai the southern part of the area is represented with fair correctness but in the northern part much that is Eocene is not shown. Similarly in Hull's map published with his memoir on Western Palestine, the whole of the southern part is shown as Eocene, whereas the main rock there is Cretaceous. Walther's map is on the whole the most correct published although he appears to be mistaken in putting as Eocene an area of Newer Tertiaries on the north of Wadi Ferân. Fourtau * recognised no nummulitic rocks until the Wadi Ferân is reached, and his description of this area is largely based on that of Walther.

(a) *Upper or Bartonian.*

In the following account, it is endeavoured to divide this formation as far as possible, in the absence of fossil determinations for all the

* Op. cit.

areas, into Upper, Middle, and Lower Eocene. Beginning with the Upper first, this division, as far as is at present known, occurs only in
Gebel Abiad. patches capping the range known as Gebel Abiad, lying to the north of Wadi Abu Qâda. On the point overlooking this wadi there were the following beds:—

Top.

1. Calcareous beds with hard layers in them; the softer laminæ contain *nummulites* and other *foraminifera*
2. Nodular beds containing derived nummulites.
3. Whitish limestone containing nodules of nummulitic rock, as well as *Operculina*, etc., thickness 15 metres.

This lay unconformably on the Gryphæa limestone of the Cretaceous. This deposit dips about 5° to the S.W. In another point of this range the white limestone bulked larger than in the first, but it also contained the rounded pebbles of nummulitic limestone and its thickness was about 90 metres, the same bed underlying it as in the first, while its dip was 5° N.E. To the east this bed lies against and upon the Cretaceous marl, and is faulted down against the Nubian sandstone at the foot of Gebel el Ti. Further north near the extreme end of Gebel Abiad at the head of Wadi Abiad (northern drainage of that name) the thickness of this deposit was found to be 116 metres; but the floor on which this deposit has been laid down is evidently very uneven, for, sometimes only 30 metres are seen, and in the case of the wadi close to the hill where the greatest thickness was found, only half that thickness was obtained. In Wadi Abiad the junction between this deposit and the underlying rock is very marked. The lowest bed consisted of rounded blocks of hard nummulitic limestone about the size of a man's head, with little or no matrix between, let into pockets like "potholes". The underlying bed contains nummulites, the Cretaceous bed having disappeared. In the hill where the greatest thickness was found, a bed full of blocks of foraminiferal limestone with a matrix of soft limestone was also seen.

From specimens from this area sent for determination to the Natural History Museum, London, Chapman * has recognised the following foraminifera:—

Globigerina bulloides, d'Orb.
Operculina complanata, (Def.) var. *discoidea*, Schwager.
Nummulites planulata, Lam.
do. *variolaria*, Lam.
Orbitoides dispansa, Sowerby.

* Geol. Mag. Dec. IV. Vol. VII, 1900, pp. 308–316, and 367-373.

From these Chapman concludes that this deposit belongs to the Bartonian or Upper Eocene. Blanckenhorn * has criticised this adversely and refers the deposit to the Miocene, but the writer is unable to agree with him in this view, as the field evidence is all in favour of its being Upper Eocene, the strong unconformity representing the break between the Middle division and this.

The strongest argument in favour of the present determination lies in the absence of pectens, echinids, and ostrea, all of which are present in abundance in the other undoubted Miocene deposits met with in this area. This point was kept in mind by the writer while examining the beds, and a careful search was made for other fossils with negative results.

(b) *Middle or Parisian.*

Coming now to the Middle Eocene, it forms the cliff of Gebel el Ti from where it bends away eastward opposite Suez, through Gebel Raha, Sudr, and Sin Bisher, a little south of which it descends into the plain running as far south as Gebel Abiad where it passes under the Bartonian ; it emerges again further west and forms Gebel Um Adam and Sanâfa, its southern limit being almost on Wadi Gharandel. It contains *Nummulites Gizehensis* in the cliffs of Gebel Raha, while further south it is full of smaller nummulites and small foraminifera. No pelecypoda were seen at any point where it was examined, it being in general, a white chalky limestone.

The next place where these beds occur is in the range of Hammâm Farûn and Usêt, † where there is a great thickness of nummulitic rocks, containing similar foraminifera to those found in Gebel Krêr. This range presents a steep escarpment to the sea, the dip at this point being practically nil, but when examined a little further to the east it is inclined at an angle of 10° thus showing that there is here a broken saddle the western limb of which has sunk under the sea. In this range the boundary between the Eocene and Cretaceous rocks has not been seen to the south but it undoubtedly occurs near the walls of Wadi Ethal. On the east of the sedimentary area and dipping west at angles varying between 8° and 30° occurs another patch of Eocene rocks forming the range of Gebel Krêr. † In this range the Eocene has been thrown down to the east against the Cretaceous marls, while a

Gebel Hammam Farûn and Uset.

Gebel Krêr.

* Zeitsch. d. Deutsch. Geol. Gesell., 1900, pp. 417-418, 1901, pp. 75-79.

† See Section IV.

duplicate ridge of the former is formed further west. Further to the north, although the fault is continued, the throw is not sufficient to expose the marls and the two ridges become one. In this ridge is a series of limestones crowded with foraminifera, samples of which have been examined by Chapman * who recognises the following genera and species of foraminifera:—

Bolivina punctata ? d'Orb.
Globigerina bulloides, d'Orb.
do. *conglobata*, Brady.
do. *cretacea ?* d'Orb.
Discorbina rugosa, d'Orb.
do. *globularis*, d'Orb.
Rotalia calcaliformis, Schwager.
Nummulites subdiscorbina, De la Harpe.
Nummulites curvispira, Meneghini.
do. *Gizehenzis*, Ehr., var. *Pachoi*, De la Harpe.
Orbitoides dispansa, Sow.
do. *ephippium*, (Schlotheim).
do. *papyracea*, Boubée.

Ridge between Gebel Abu Alaqa and Mokateb.

From specimens collected underneath this horizon it was found that this ridge was composed of both Middle and Lower Eocene. For the general relations of the beds in this area see Section IV. After this locality no more Middle Eocene is found until the ridge between Gebel Abu Alaqa and Gebel Mokateb is reached where a rock crowded with *N. Gizehensis* and a smaller species is found underlying the Miocene deposits. This overlies the Cretaceous and sweeping round its flank crosses Wadi Ferân and extends down as far as Wadi Khadâhid, being inclined at angles varying between 32°, 60°, and 80°. At Wadi Khadâhid this bed contained numerous oysters and echinoderms, while at the base of the limestone were several fish-teeth. In a sample from this place Chapman* has recognised the following foraminifera:—

Wadi Khadâhid.

Truncatulina umbonifera, Schwager.
Nummulites gizehensis, var. *Pachoi*, De la Harpe.
do. *curvispira*, Meneghini.
do. *Barroni*, sp. nov., (Chapman).
do. *Ramondi ?* Defrance.

Gebel El Rigma.

At the top of Gebel el Rigma† these beds are found underlying the Miocene Deposit. They have been let down by a fault against the

* Loc. cit.
† See Section. II.

Cretaceous marls. To the east of this beyond the cliff, the Eocene beds have again been let down by a fault against the *Gryphœa* bed of the Cretaceous, and are inclined towards the cliff at an angle of 30°. The beds at this place are full of echinoderms and oysters ; of the latter the following have been determined :

Ostrea rarilamella, Desh.
Ostrea Clot-Beyi.
Ostrea Fraasi, M.E. = *O. elegans*, var. *exogyroides*, Oppenh.

To the south-east of this point these beds form the surface of the plateau resting against the gneiss and igneous rocks of the Central range; their characters are very constant all through except that here they contain thin beds of nodular limestone. Where this area was examined it was dipping at 30° to the east. Further west, near the mouth of Wadi Thaghadi, nummulitic limestone occurs on the top of the plateau overlooking this valley and faulted down against the Nubian sandstone. It also caps the hill on the east side of Wadi Abura, and underlies the Miocene deposits near its mouth. In Gebel Asfar this bed likewise underlies the Miocene deposits on one side at least, dipping steeply under them and apparently forming a sharp fold by which the older beds are made to appear on the east. It also appears in Gebel Safariat where it is dipping steeply at 55° towards the hills. (A section is given in the chapter on the Cretaceous, p. 134, in which the various beds of this formation are shewn). These beds are full of large nummulites, oysters, and the gasteropod *Thersitea* while a few corals were also found. * Amongst the large nummulites Chapman † recognised the following species.

Gebel Safariat.

Nummulites gizehensis, (Forskal), var. *Ehrenbergi*, De la Harpe.
„ „ var. *Lyelli*, d'Archiac and Haim.
„ „ var. *Pachoi*, De la Harpe.

On the west side of the sedimentary area near the sea-coast at the mouth of Wadi Ferân is a small hill called Khadêd el Dhib where this rock occurs. It is the same as is met with on the east, and has been thrown down by a fault hading west, the beds themselves dipping west at 30°. Along the shore side of Qabelîat a small patch of this rock has been thrown down against the Cretaceous marls.

Gebel Khadêd el Dhib.

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* See list of fossils at end of chapter.
† Loc. cit.

Gebel el Araba. In Gebel el Araba, however, this bed is continuous for a long way under the Miocene deposits. In Wadi Qabeliât, where the Miocene deposits have been faulted, the nummulitic bed is found immediately underneath. Higher up the cliff this bed is again found forming a small platform at the foot of the next patch of Newer Tertiaries which is faulted down from the main cliff. It also occurs in the main cliff in the same position as in the others. (For the general relations of these beds see Section I.) Here the dip was about 22° while that of the overlying Miocene was 12°. The nummulitic bed does not extend the whole length of the ridge of El Araba, as it was absent about 22 kilometres further south. Between it and the overlying deposit there is a bed of conglomerate composed of pebbles of nummulitic limestone.

(c) *Lower Eocene.*

There now remains to be described the occurrences of the Lower Eocene or Libyan series. There are only three known places where it occurs at present, viz. Gebel Krêr, * a small hill at the confluence of Wadis Baba and Shellâl, and in Gebel Safariat. In the first of these places these beds occur between the Middle Eocene and the Cretaceous. In a specimen from this place Chapman † recognised the following foraminifera:—

Miliolina circularis, Born.
Alveolina boscii, Defr.
„ *decipiens*, Schwager.
Bigenerina (?) nodosaria, d'Orb.
Globigerina Cretacea ? d'Orb.
Operculina complanata. Defr. var. *canaliculata*, d'Arch.
Nummulites Guettardi, d'Arch. and Haime, var. *antiqua*, De la Harpe.
Orbitoides dispansa, Sow.
„ *papyracea*, Boubée.

Gebel Krêr. From these he concluded that these beds were of Libyan age. In the cliff of Krêr the thickness of Eocene limestone is at least 104 metres, but how much is Middle and what is Lower Eocene it is impossible to say without a careful examination. It is however certain that the Libyan beds form the smaller part of the cliff.

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* See Section IV.
† Loc. cit.

At the junction of Wadis Shellâl and Baba, these beds form a small hill of which the following is a section:— Junction of Wadis Baba and Shellâl.

Top.

1. Crystalline limestone with a bed of foraminifera at its base.
2. Gypseous marls containing *pectens* and *Echinolampas*, as well as layers of flints from the Cretaceous.
3. Beds of rounded and angular flints, lying unconformably on the Cretaceous.

In this rock Chapman * recognised these fossils :—

Textularia agglutinans, d'Orb.
Operculina complanata, (Defr), var. *canaliculata*, d'Arch.
Nummulites Ramondi, Defr.

It is not known at present whether this one little hill is the whole of the Lower Eocene in this area, as the specimens from it are not yet determined.

One striking difference between the eastern and western shores of the Gulf of Suez is the absence of the Esna shales and the flinty limestone series so common on the Egyptian side. In no place have they been met with, and it would apear that while they were being deposited to the west, Sinai was a land surface undergoing denudation and degradation, the upper part of the Cretaceous being removed prior to the deposition of the Lower Eocene. In the northern half of the peninsula, denudation has been much more active, the whole of the Upper Cretaceous or Danian being absent, and nearly the whole of the 400 metres of the Senonian having likewise been carried away. From the general appearance of the rocks it would seem as though there had been a rapid subsidence, and the lower rocks were deposited in deep water, that after the Lower and Middle representatives had been laid down an elevation took place, (the most of the land having previously sunk beneath the sea as evidenced by the presence everywhere of Middle Eocene) during which there was a certain amount of denudation by which the unconformity seen in Gebel and Wadi Abiad was produced, while later a second subsidence took place to allow of the deposition of the Upper Eocene or Bartonian, the lower rocks being exposed so as to undergo degradation and furnish the pebbles and boulders seen in that deposit. Overlap must also have taken place as Bartonian beds are found on Cretaceous marls.

* Loc. Cit.

EOCENE FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

Gebel Safariat.

Odontaspis macrotus, Agass. (Suessonian).
Turritella Boghosi, Cossmann („).
Thersitea gracilis, Coq. („).
Thersitea, sp. nov.
Tectus, cf. *ornatus*, Lam.
Scaphander sp.
Ostrea Fraasi, M.E. = *O. elegans* var *exogyroides*, Oppenheim.
Carolia placunoides, Cautraine.
Meretrix sp.
Callista suberycinoides, Desh.
Echinolampas Crameri, Loriol.
Heliastraea sp.
Astrocœnia.

Gebel el Rigma and Wagraf.

Ostrea rarilamella, Desh.
do. Clot-Beyi.
Ostrea Fraasi, M.E. = *O. elegans* var. *exogyroides*, Oppenh.

Gebel el Araba.

Ostrea rarilamella, Deshayes.
Carolia placunoides, Cautraine.
Spondylus Egyptiacus, R.B. Newton.
Meretrix sp.

Wadi Khadahid.

Ostrea sp.
do. Reili, Fraas; associated with *N. Gizehensis* and *N. curvispira.*
Ostrea Fraasi, M.E. = *O. elegans* var. *exogyroides* (Oppenheim).

Wadi Abu Qâda.

Ostrea sp.
do. Fraasi, M.R. = *O. elegans* var. *exogyroides*, Oppenheim.
Plicatula polymorpha, Bellardi.
Spondylus ?
Bryozoa.
Linthia (basal fragment).

Gebel Um Adam.

Conoclypeus conoideus, Lam.

Section IV.—THE CRETACEOUS LIMESTONE AND SHALES.

These rocks occur all over the western side of Sinai from Gebel Saidna Musa on the south to Wadi Bagha on the north. They have been described more or less completely and with varying degrees of exactness by various writers. In 1866 the Rev. F.W. Holland, who was afterwards attached to the Ordnance Survey party deputed to make a survey of the country, with a view to elucidate some doubtful points in the journeying of the Israelites, visited the main areas and published a map geologically coloured shewing the boundaries of the different formations, but on account of the large area attempted in the time and the inability to visit sufficient points in order to fix boundaries he went widely from the mark in several places.

Bauerman * in 1868 visited the district between Suez and the lower part of Wadi Ferân. His object apparently was to examine the old mining centres there; but he formed a very correct idea of the various formations in this district, much more so than some of the more recent observers.

From the hill at Naqb el Budra he obtained the following fossils which were named by the late P.M. Duncan, F.R.S.:

Epiaster distinctus, Agass.
„ *tumidus*, Desor.
Periaster oblongus, d'Orb.
Hemiaster Cenomanensis, Cotteau.
Physosoma Delamarrei, Desor.
Plicatula Fourneli, H. Coquand.
Pecten asper, Lamb.
Neithia alpina, d'Orb.
„ *tricostata*, Bayle sp.
Exogyra plicata, Goldfuss.
Ostrea Auressensis, H. Coquand.
„ „ var. *major*. Duncan.
† *Exogyra Overwegi*, Buch.
Ostrea curvirostris, Nielson.
Radiolites sp.

From Wadi Ferân he obtained the following fossils.

Hemiaster Cenomanensis, Cotteau.
Ostrea Auressensis, H. Coquand.

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* Op. cit.

† This is probably *Exogyra Olisiponensis*, as *E. Overwegi* is not known below the Danian.

From Gebel el Ti the following were collected.

Discoidea subuculus, Klein.
„ *Forgemolli*, H. Coquand.
Periaster oblongus, d'Orb.
Hemiaster Cenomanensis, Cotteau.
Pseudodiadema variolare, Brogn. sp.
Exogyra plicata, Goldfuss.
Ostrea Auressensis, H. Coquand.
* *Exogyra Overwegi*, Buch.

From these fossils and a study of those previously collected by the Rev. F. W. Holland, Duncan came to the conclusion that the most of the Cretaceous rocks belonged to the Cenomanian, but that there was also evidence to support the assertion that the Turonian as well as the Cenomanian was present. He based this view on the reported presence of *Hippurites* in the El Ti section examined by Dr. Le Neve Foster, and also the finding of some of these in Wadi Budra by Bauerman.

These *Hippurites* are however found too low in the series, as the writer has found the bed underlying others containing Cenomanian fossils. The *Hippurites* are in reality *Sphaerulites*, which occur in the Cenomanian.

In 1869 the Report of the Ordnance Survey of Sinai was published. This contains a chapter on the Geology of the Peninsula by the Rev. F.W. Holland,† to which is appended a list of fossils collected by the author, the Survey Officers, and others added on the authority of J. Salter. The fossils collected by the Survey are marked (*) those by the Rev. F.W. Holland (H) and those added by Salter (S). They are arranged by localities.

1. Gebel and Wadi Mokateb.

* *Strombus* cf. *mermeti*, Coq.
* *Turritella* sp.
* *Astarte pumica*, Coq.
* „ *obrutus*, Conrad.
* „ *subcordata*, Conrad.
* *Cardita* sp.
* *Isocardia orientalis*, Conrad sp.
* „ *æqualis*, Conrad sp.
* *Lavignon Baylei*, Coq.
* *Plicatula Fourneli*, Coq.

* This is probably *Exigyra Olisiponensis*, as *E. Overwegi* is not known below the Danian.
† "Ordnance Survey of the Peninsula of Sinai," 1869, Pt, I.

* *Ostrea mermeti.*
* „ *plicata* Goldf. (=*O. Overwegi*, Coq., *O. Boussingaulti* Conrad).
* „ *Dellatrei*, Coq.
* *Ostrea syphax*, Coq.
* *Epiaster tumidus*, Desor.
* „ *minimus.*
(H) *Hemiaster gracilis.*
(H) *Holectypus excisus*, Desor.
* (H) *Heterodiadema libycum*, Desor.
* *Nucleolites similis*, Desor.
(H) *Periaster elatus*, d'Orb.

2. Naqb Budra.

* *Arca Tevesthensis?* Coq.
* *Astarte Fatma?* Coq.
* „ *Gabæ?* Coq.
* (S) *Pecten asper*, Lamk.
(S) „ *alpina*, d'Orb.
(S) „ *tricostata*, Coq.
* *Ostrea plicata*, Goldf.
* „ *curvirostris*, Nil.
(H) (S) *Epiaster distinctus*, d'Orb.
(S) *Periaster oblongus*, d'Orb.
* *Physosoma Delamarrei*, Desor.
(H) *Pseudodiadema Rupelli.*
(S) „ *variolare*, Brongn.

3. Other Localities.

* *Turritella Tenouklensis*, Coq. Wadi Sadur.
* (S) *Pecten asper*, Lamk. Gebel Abu Alaqa.
* „ *Marrotianus*, d'Orb. Wadi Sadur.
* „ *obrutus*, Conrad.
* *Protocardium Hillanum*, Sow.
* *Ostrea dentata*, Conrad (=*O. Auressensis* Coq.) W. Ferân.
* „ *Mermeti*, Coq. Wadi Shellâl.
* „ *Dellatrei*, Coq. Wadi Shellâl.
* „ *Forgemolli*, Coq. Wadi Ferân.
* „ *vesicularis*, Goldf. Gebel Bisher.
* „ *flabelliformis*, Nills. Wadi Wardân.
* „ *costata*, Say. Wadi Ferân.
(S) *Discoidea subuculus*, Klein. El Ti.
(S) „ *Forgemolli*, Coq. El Ti.
(S) *Hemiaster Cenomanensis*, El Ti.
(S) *Periaster oblongus*, d'Orb. El Ti.
(S) *Pseudodiadema variolare*, Brongn.

In these lists of fossils nearly all the evidence points to the age of the Cretaceous beds being Cenomanian. The occurrence of *Ostrea vesicularis*, Goldf., suggests the presence of Senonian beds in the locality where it was found. It will be seen however from the subsequent pages that this locality is not a solitary instance, this fossil having been noted in several other places all over the district.

Following this observer came Hull * in 1883 who, however, only visited the upper part of the sedimentary area, but in the map which he publishes he perpetuates the errors of the previous observers having compiled its southern portion from the already existing sheets.

In 1888 Walther † published an account of a journey in Western Sinai in which, although his time was mainly devoted to unravelling the history of the coral reefs past and present, he gives a general account of the country through which he passed. Where he has actually examined the rocks he does not go far from the mark except in some particulars, e.g. in shewing a large area of Miocene as nummulitic limestone, and his interpretation of the structure of Qâ plain and the ranges on either side.

In 1898, the year in which the work embodied in this report was done, Fourtau ‡ published a series of papers describing the geology of Western Sinai of which the following is an epitome. In Wadi Tayiba he states that he found some marls containing the following fossils.

Ostrea Mermeti, Coq.
Lucina cf. Safedensis, Conrad.
Crassatella cf. Falconieri, Lartet.
Hemiaster Heberti, Peron and Gauthier.

From these he concludes that these marls are of Cenomanian age. As will be shown later none of these beds occur in the lower part of the wadi which Fourtau traversed, but are only found a few kilometres further south. He likewise states that a bank of diorite has cut through the Cretaceous limestone at the mouth of Tayiba, by which the beds have been metamorphosed. As a matter of fact the igneous rock is not intrusive but an interbedded lava not in Cretaceous but in Tertiary beds. At Wadi Zafarâna and Legâm the section he gives, although in the main correct, has made the limestone forming the top of the hill upper Cenomanian, whereas it has been shewn to belong to the Libyan stage of the Eocene. At this place he finds *He-*

* "Geol. and Geog. of Arabia Petræa," Palestine, etc., 1885.
† "Die Korallenriffe der Sinai Halbinsel," 1888.
‡ Op. cit.

miaster cubicus, Desor, and *Ostrea Mermeti*, these proving the rocks to be of Cenomanian age. After passing to the mouth of Wadi Budra he examined the marls which there occur in a thin strip. Here, he says, on the west side of Wadi Sêh Sidri, the Cretaceous rocks reach their maximum thickness of about 400 metres. From the marls he obtained the following fossils.—

Hemiaster cubicus, Desor.
„ *Heberti*, Peron et Gauthier.
Holectypus Cenomanensis, Gueranger.
Ostrea Mermeti, Coq.
Exogyra flabellata, d'Orb.
Ostrea Africana, Lam.
Astarte amigdala, Coq.
Plicatula Reynesi, Coq.
Isoarca aquilina, Coq.

Strangely enough these fossils are all of Cenomanian age, and the large mass of beds above these have yielded no fossils. This is as it should be, for the limestone beds which Fourtau regards as Cretaceous, are remade rocks of Younger Tertiary age, while the true Cretaceous rocks are not 40 metres thick at this place.

In describing the plain of El Qâ and the coast-range of El Araba he has evidently followed Walther as he describes it as a syncline and shews it as such in his Fig. 4, failing to recognise the fault which breaks it on the east, or the mass of Miocene beds which cap the Araba ridge, and which he shews as nummulitic limestone. In the chapter on the hydrology of this district he makes some diagrams to explain the presence of wells in certain places. In the case of the Ên el Markhâ his Fig. 6 shews a granite floor holding up the water. This differs essentially from the views formed by the writer on examination of the district. First of all he makes the Nubian sandstone to nip out within the space of a few kilometres, as none is shewn in the section, while, secondly, the granite does not exist except at over 600 metres below the surface, the whole country having been let down by a huge fault to over that extent. The true cause of the well is the holding up of the water by the shaly and marly beds of the Cenomanian. He likewise states that the springs of Hammam Farûn and Hammam Saidna Musa have the same origin. It is, however, much more likely that both of them come up fault-planes since a fault passes along the foot of Gebel Hammam Farûn, while one has been inferred at the foot of the range where the latter spring issues. From the analysis of the former water there seems little doubt that it is derived, in part at least, from the sea,

as no other hypothesis can explain the large percentage of salts in it, nor can it be understood how it derives its supply, which is perennial, from a comparatively rainless district.

Having now noticed the previous work on this district it is necessary to give an account of the observations made by the writer.

Gebel el Araba. Starting from the most southerly extension of these rocks the first to be described is the El Araba range. On entering the range a section of the main or eastern ridge was examined in which the following beds were seen, although unfavourably placed for measuring the thickness:

Top.

1. Limestone with flint-bands.
2. Pinkish limestone.
3. Marly limestone.
4. White limestone.
5. Flinty limestone.
6. White limestone with *Gryphæa vesicularis*, var. *judaica*, Lart.
7. Gypseous Marl.
8. Marly limestone with *Exogyra flabellata*, Goldf., and *E. Mermeti*, Coq.
9. Sandy clays and marls with calcareous sandstone.
10. Sandy beds.
11. Nodular limestone.
12. Marly beds with small *Ostrea*.

This was succeeded by the Nubian sandstone. The dip was eastwards at an angle varying from 10° to 15°.

Further up the Wadi el Araba an attempt was made to obtain an approximate thickness of these beds, but as they were steeply tilted and it was impossible to measure them on account of steep, unclimbable scarps the thicknesses here given are only approximate, being estimated by eye:

Top.

1. Grey marls with three thin beds of limestone	9	metres
2. Yellow marls with two metres oyster bed	10·5	„
3. Yellow shale with ferruginous limestone at top	4·5	„
4. Oyster limestone*	3	„
5. Mixture of marls and thin limestones with greenish shales at top.	15	„
6. Mixture of sandy beds and marls with a thin limestone and oyster bed.	15	„
7. Marly limestone with beds of dark shale and hard ferruginous bed at top	7·5	„
8. Nodular and thin-bedded limestone with marly partings	9	„
9. Grey sandy and marly beds	9	„

* See list of fossils at end of chapter.

10.	Marls with bed of limestone at top full of *radiolites* ...	6	„
11.	Nodular limestone	6	„
12.	Sandy, marly, yellow limestone	21.5	„
13.	Oyster limestone	3	„
14.	„ „ with marly beds...	12	„

The total thickness is not less that 131 metres and may be over it. Below this series comes the Nubian sandstone which is dipping about 10°, while the marls above it fall away to the east at an angle of 12°, the overlying limestone being inclined at 20°. This latter dip was obtained from a very small exposure and is not to be relied upon; the general inclination is 12°, as deduced from several other observations.

About half-way up the range, where the upper Wadi el Araba passes out to sea, the beds have been thrown forward by a dip-fault a distance of 3 kilometres. Following up the marls from the last place at which they were examined they are seen to come to a sudden stop against the upper Cretaceous limestone, at the same time swinging round sharply until their direction of dip is at right angles to their normal bearing, their inclination rising from 12° to 30°, 50° and 60° within the space of four kilometres. Hitherto the true limestones of the Cretaceous have been confined to the main cliff of Gebel el Araba, but beyond this fault they suddenly spread out and occupy the secondary ridges, gradually merging into the range of Qabeliat; the main cliff at the same time becomes lower and gradually loses itself in the dip-slope of this hill-mass. To the south of the fault the conditions are reversed; the limestones form the cliff only; while the marls occupy a series of parallel ridges at its foot, each ridge being due to the limestone beds noted in the above section.

To the north of the dip-fault there is a steep escarpment of the marls sharply tilted to the north at an angle of about 80°, which bends round until it assumes a direction parallel with its original line. The Cretaceous limestone also owes its great horizontal extension to reduplication by step-faulting, the throw never being great enough to bring up the marls. The general trend of these fractures is more or less parallel with the main cliff, and in no case do they cross the dip-fault. The most westerly ridge is capped by Miocene deposists underlaid by nummulitic limestone (*N. Gizehensis*) which directly overlies the Cretaceous limestone.

The Miocene lies in the form of a shallow syncline on the top, while the Cretaceous limestone shows dips ranging from 22° to 35° to the east. The fault which has thrown down this ridge is evidently conti-

nued in the direction of Qabeliat where it dies out, the wadi of this name having formed along its course. Further to the east two more faults were found parallel to this one, the throw of each of this series, as determined by the position of the nummulitic bed being 49 metres, 30.5 metres and 104 metres, going from west to east. For the general appearance of the rocks at this place see Section I. In all the sections here the nummulitic beds were found between the Miocene and Cretaceous, although some distance further to the south they were missing.

Gebel Qabeliat. Passing north to the hill-mass of Qabeliat *, it is convenient for descriptive purposes to separate it from the Cretaceous to the north of Wadi Ferân, making this valley the northern boundary for the present. This hill-mass presents on its western face a steep escarpment which is unscalable in many places, and is cut up into narrow ridges by deep gullies sloping eastward; it is capped on the north, where it was examined, by Miocene limestone, the southern ridges having lost this covering. The nummulitic bed was not seen beneath the Miocene at this point, but it must exist in places, as it was found thrown down against the marls farther south. Forming secondary ridges at the foot of the escarpment are the marls with the Nubian sandstone at their base. In the main mass it was impossible to get a measured section, but the succession was very similar to that in Gebel el Araba. The marls dip eastward at an angle of 18°, while the overlying limestone is less steeply inclined. In the nodular bed in the marls specimens of *Nerinæa* were found, associated with these being several ammonites. Further to the south, a north and south fault has thrown down the Cretaceous limestone and marls against the Nubian sandstone.

On the north side of Qabeliat on the side of Wadi Ferân a section was examined in which the following beds were noted:

Top.

Miocene	1. Crystalline limestone with small echinids and a thin layer of large oysters	9	metres
	2. Limestone with echinid spines.	3	„
	3. Limestone with foraminifera	3	„
	4. Limestone with thick oysters and large pectens	3	„
	5. White, thin-bedded, marly limestones which weather into thin leaves	61	„
	6. Marly limestone with flinty layers	28	„
	7. White sandy limestone	73	„
	8. Marly limestone with few flints	18	„
	9. Marly limestone with flints	37	„
	Total Cretaceous	217	„

* See list of fossils at end of chapter.

Underneath these comes the lower limestone of the Cretaceous which as it formed the surface of the ground could not be measured here, the marls following in due order.

The hill-mass of Qabeliat is evidently the top of an anticline as there is a fall from the top to the north and south, Wadi Ferân being in the trough; it thus seems that the course of the drainage has been determined by this fold, and not by faulting, as maintained by Walther, for which there is no evidence.

Gebel Safariat.

It is now necessary to describe the mass of Cretaceous rocks which occurs on the east of Qâ plain, and lies on the flank of the igneous and metamorphic rocks of the central range. Taking the most southerly part of this area—Gebel Safariat—it is found to be much complicated by folding and faulting. It is composed of nummulitic beds on the east side followed by Cretaceous limestone and marls, these latter being reduplicated by faulting. The beds dip steeply towards the hills, being let down by the main fault which runs between the sedimentary and igneous rocks the whole distance in which they are in juxta-position. Walther * and Fourtau † give quite a different interpretation of the structure of this area. In the section by the former he shews this area to be a simple anticline broken by the main fault along the edge of the hills, the range of El Araba being connected to it by a syncline. In this section he shews Eocene rocks on the east side, which is correct, but he can hardly have examined the rest of the rocks, as the beds, instead of dipping west as he shows them, have a strong easterly dip, and instead of Cretaceous limestone forming the west side, it is bounded by the marls. The section of Fourtau, although the place is not quite identical with that of Walther, resembles certain of the latter's sections, but he makes nummulitic limestone appear on both sides of the hill, which does not agree with the facts of the case, there being no evidence to enable any one to deduce an anticlinal structure for this area.

The following is a detailed description of this hill. On the east side, as previously stated, it is covered by nummulitic beds dipping steeply eastward at an angle of 50°, which also extend some distance on the south side. Underneath these comes the limestone of the Cretaceous which seems to pass insensibly into the overlying beds although the dip as seen a little further back is much smaller. The general appearance of the area points to the conclusion that this has at one time been a dome subsequently broken by a big fault and much disturbed by

* Op. cit.
† Op. cit.

smaller ones, the main fracture being connected with that which has let down the beds on the east side of the Qâ plain.

In the middle of the area the marls are lying almost horizontal while towards the north they are inclined in that direction at an angle of 15°. The following is a section of the limestone with some measured thicknesses and the others estimated by eye.

Top.

1. More or less crystalline limestone containing *Nummulites Gizehensis* and corals	21.5	metres
2. Beds full of *Thersitea* casts	3	„
3. Hard crystalline limestone with soft partings and containing fossils near the top	11	„
4. Shelly, marly limestones. These are Eocene in age...	5.5	„
5. Coprolite-bed with fish teeth	1	„
6. Shelly, marly, crystalline limestone containing dog-tooth spar...	12	„
7. Hard crystalline beds with layers of flint	31	„
8. White chalky limestone with numerous thin layers of flint	18	„
9. White, chalky limestone with *Gryphæa vesicularis* var. *judaica,* Lart.	9	„

Below this come the Cretaceous marls.

On the west of the main escarpment where the above section was examined, a small knoll of the *Gryphæa vesicularis* limestone is let down by a fault against the marls and has a dip of 50°. On the extreme west of this area these beds again appear let down along a north-and-south line and having a steep dip of 50° on either side of the fracture. On the north side a small patch is also found dipping north-east at 30°.

In the marls there is a general dip (where not disturbed by faults) of 10° to the south-east; but on the north side, where they come under the influence of faults, they are inclined at angles of 8°, 15° and 30°, north-west, north and north-east respectively. Two faults run more or less east and west down the wadis, and it is due to these that the marls occupy so much of the ground. In these beds a good many echinoderms, *radiolites* and *Ostrea* occur.

Gebel Asfar.

Passing northwards the main sedimentary area is first touched at Gebel Asfar. At its base the whole of the succession found in Gebel Safariat except the Coprolite-bed is seen. In climbing the hill the marls are seen dipping towards the igneous range at an angle of 30°; but as the limestone was crossed, the beds were seen to go under the Miocene of Gebel Asfar in a north-easterly direction at an angle of 20°. North of this hill in Wadi Raqqa the marls are seen inclined away from

the hills at an angle of over 60°, while the overlying limestone dips at 30°. On the west side of the ridge, however, the opposite is seen, the limestone dipping at 50° towards the hills, thus showing that there is an extremely sharp fold which has been broken by the line of fault bounding the igneous rocks. This fold is continued more or less parallel with the hills but the dips are not nearly so steep, being 8° and 5° respectively east and west.

From Gebel Asfar to the mouth of Wadi Abûra the marls form the sides of the hills, but in this wadi Miocene beds are found capping them, and lying unconformably on the *Gryphæa* limestone and the marls. Between this hill and the high plateau to the east the marls extend in a fairly broad strip, being evidently exposed by the breaching of the anticline of Cretaceous limestone, which appears in the plateau to be about 183 metres thick.

On the north side of Wadi Abûra a long strip of Miocene deposits rests on the marls which have a general trend to the south, the land rising and the limestone coming in and thickening as it is followed northwards. This is capped by the nummulitic bed which lies in a shallow syncline, and is let down along the side of Wadi Thaghadi against the marls. Between Wadi Abûra and Abu Gurdi the marls on each side of the plateau are dipping south at 15°; while at Gebel Thradi which forms the divide between the latter wadi and that of Thradi, there is a patch of Cretaceous limestone dipping south-west at angles of 50° and 60°. Further north where the marls are exposed, their dip is over 80°; while only a little distance back at the top of Gebel Thaghadi they are only inclined 5°. It thus seems fairly certain that this steep dip is the result of a fault which has broken the syncline, dragging down the beds as they gave way.

In this section the beds appear in a very sharp flexure on the upthrow side of the fault, while immediately behind this they are lying horizontal. It would seem that when the flexure which ended in a fracture became acute, the beds offered such a strong resistance to it that they were dragged almost into a vertical position before they finally gave way. This points rather to a comparatively sudden movement, than a slow, gradual flexure and fracture.

Wadi Thaghadi.

On the north side of Wadi Thaghadi another small patch of Cretaceous limestone occurs dipping at 80°, while behind it the marls are inclined at 5°; the relations of the beds at this point are shown in Section I.

Gebel Abiad.

North of Wadi Abiad occurs Gebel Abiad, a hill of Cretaceous limestone tilted at 80° to the south-west, and presenting a steep scarp to the

north-east. There is a small fault behind this hill throwing down to the east which is continued across Wadis Themâm and Abu Gallam behind Gebel Khadâhid.

Gebel Khadahid.

In this hill the following sequence was seen in the wadi of the same name, the beds having the same steep dip at first, but falling back rapidly to a gentle slope :—

Top.

1.	*Nummulites Gizehensis* bed with various oysters, echinoderms, and foraminifera over	30 metres (Eocene)
2.	White, marly, fissile limestone, about	21 „
3.	White limestone with layers of flint	18 „
4.	Hard, white, marly limestone with fissile partings, about	76 „
5.	White marly limestone weathering pink, with flint layers at top..	9 „
6.	Thin-bedded flinty limestone	6 „
7.	White, chalky limestone with *Gryphæa vesicularis* var. *judaica*, Lart.	9 „
	Total	169 metres

As will be seen the thicknesses are not accurately determined and must not be taken as absolute.

Wadi Ferân.

The next place where this area was examined was in Wadi Ferân,* where a large mass of flinty limestone slopes westward to the wadi, culminating in the peak of Gebel Asl. These flinty limestones dip westward at 22°, and end in an abrupt escarpment which tapers to such a narrow edge at the top that it is dangerous to attempt to walk along it, while it is impossible to walk on the slope of the flinty beds on account of their slippery surface. The height of Gebel Asl above the wadi level is 460 metres which, taking the dip as 22° as determined, and plotting it out on paper, shews a thickness of 420 metres of limestone. This seems rather exaggerated but as the height was obtained by aneroid in descending the cliff there may be a slight error. At the same time it is fairly near that given by Schweinfurth for the limestone in Wadi Araba, viz. 380 metres.

On the south side this limestone swings round to the east evidently forming the remains of a dome, and is cut off by a fault running in an east-and-west line, the marls being brought up against it.

At the foot of this escarpment the marls come out and rise towards the east with a slope of 25°. Further east is another ridge of limestone

* See Section II.

of the same nature as the first, rising in terraces from the wadi, and dipping westward at 32°. It is let down by a fault against the marls, this being accountable for the very steep dip. On the highest point occurs a patch of Miocene which, with the *Nummulites gizehensis* bed, lies in a sharp syncline broken by the fault throwing down the Cretaceous limestone against the marls, the nummulitic bed being let down against the *Gryphæa vesicularis* limestone and the upper beds of the marls. The Cretaceous limestone is evidently continuous underneath this patch and forms a sharp, V-shaped bend, the east limb of which dips 32° to the west, and forms a steep scarp facing east. At the base of this the marls are seen, but when followed northwards they narrow and are finally nipped out by a fault running north-west-south-east, which has thrown down the nummulitic bed and the *Gryphæa vesicularis* limestone against them. This fault is continued across Wadi Ferân and dies out at the head of Wadi Mokateb. Underneath the nummulitic beds and the Cretaceous limestone, the marls again appear on the east side, forming a fairly high escarpment, and they occupy both sides of the wadi at this point, their dip below the overlying beds being 15° to the west. Further to the south-east, the cliff of Cretaceous limestone which lies immediately behind the Miocene becomes connected with the main mass of which Gebel Asfa or Asl forms the summit, the high limestone area abutting on the gneiss and granite of the main range, and being let down by the main fault. Along the edge of the fault it is capped by the nummulitic beds which dip towards the fault at angles varying between 20° and 30°.* To the west of the limestone is a large area of marls which occupies the country from the neighbourhood of Wadi Thaghadi, up to the fault which throws down the limestone of Gebel Asfa against them. On the east side of the limestone ridge the marls, as they are followed to the south-east, are gradually nipped out by the fault which here has a fairly large downthrow.

Gebel el Rigma.

It is now necessary to consider the origin of Qâ plain. Walther † is the only one, as far as is known, who has made a definite statement illustrated by diagrammatic sections, while Fourtau ‡ has followed his lead. Their explanation is, that it is a syncline in which Newer Tertiary deposits have been laid down. On referring to Section I however, which has been drawn to scale, it will be seen that instead

Origin of Qâ Plain.

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* See Section I.

† Op cit.

‡ Op. Cit.

of the nummulitic beds lying on either side of the trough as shown by Walther, they are covered by Miocene beds, on the west side much step-faulted, while on the east both of these formations are absent, having been thrown down under the surface by a large fault, and the Cretaceous limestone has been tilted at 80° by the fracturing of the beds. At the head of the plain near Wadi Ferân where the fault dies out, the conditions are more those of a syncline, although even there the beds occupying the opposite sides of the trough are not the same. From observations made in the vicinity it would seen that they had been originally homologous, but were removed later on by denudation.

It was Blanckenhorn * who evidently was the first to suggest the true state of matters from a study of Walther's map, and taking into consideration the fact that he had never visited the country, his deductions were wonderfully correct. In his paper he suggested that a fault had broken the syncline on the east and let it down, and this agrees with the observed facts. This paper will be referred to when the faults come to be described. There can be little doubt as to the correctness of the explanation here given, and it would seem probable that the above mentioned writers without having examined the ground, have formed their conclusion from insufficient data possibly collected on the sides of Wadi Ferân.

Gebel Withr.

Passing to the north of Wadi Ferân and following the plan of the description of the previous part, the coast-ranges of Gebel Withr, etc., fall next to be described. On the side of Wadi Ferân a section has already been given showing the succession of the beds in the limestone (p. 138). Gebel Withr is a ridge having a steep escarpment facing the west with the beds dipping eastward at 10° to 15°. It is composed of flinty limestone with the *Gryphœa vesicularis* bed at the base, and the marls, part of which is only visible, forming low foot-hills on the coast. On the east, the limestones have been thrown down against the marls by a north-and-south fault hading west; while on the coast a second fault has let down the nummulitic beds and the Miocene deposits against the marls, this fracture evidently continuing along the coast side of the range as far as the mouth of Sêh Sidri. On the side towards this valley the range is split into two by a wadi, the western part being known as Gebel Nisisat,† while the other retains the name of Withr. On the north side these ridges run to earth, being let down by a little cross-fault which connects the longitudinal fractures. No fossils were

* "Die Strukturlinien Syriens u. d. Roten Meeres," 1893.

† See Section III.

GENERAL VIEW OF FAULT EFFECTS AS SEEN FROM NAGB BUDRA.

observed in the flinty limestone; but in the marls below many specimens were obtained. On the east of Gebel Withr the *Gryphæa* limestone and the upper part of the marls where they are exposed from under the Miocene, are seen to be gypsumised. This will be described in the part on Gypsum. These gypsumised marls disappear under the Miocene limestones and marls.

On the east side of the Miocene deposits above-mentioned, and on the north side of Ferân the Cretaceous limestone (which is the continuation of the mass described on the south side, p. 142) forms a large mass having the same characters as those already mentioned, and a dip of 22° W. This mass gradually tapers to the north and is eventually nipped out by a fault. On its west and north-west sides the nummulitic bed * lies on it at an inclination varying from 32° to 10° to the west and north-west respectively. Below the limestone come the marls † with a fault breaking them in the middle. Further north their outcrop suddenly narrows to a mere strip, this being due to the fault previously mentioned which throws the limestone down against them. This narrow strip continues right along to the foot of Gebel Abu Alaqa where it disappears, being covered by the Miocene deposits which cap that hill.

Wadi Budra.

In this wadi the Cretaceous marls appear at the mouth in a thin streak which gradually widens out into a triangular patch, its dip at first being 25° to the west, but gradually lessening until its outcrop ceased to expand. Near the head of the wadi a small patch of the *Gryphæa vesicularis* limestone crops out from under the Miocene deposits; while just beyond the Naqb Budra, the marls rise in a fairly high hill, the base of which is formed by the Nubian sandstone. In this hill in the marls there is a bed of limestone in which occur numerous echinids and ammonites. This is in the lower half of the marls. Beyond this hill the marls widen out, being reduplicated by two short, parallel faults. To the west these marls dip away under the Miocene at 5°, being covered in many places by a bed of gypsum derived from the *Gryphæa vesicularis* bed. Further to the east a small strip of unaltered limestone appears on the edge of the Miocene deposit, while on the edge of the latter which lies opposite the Wadi Shellâl,* a strip of Cretaceous limestone forms the edge of the basin in which these beds lie, being inclined to the horizon at an angle of 63°, and let down by a fault against the Nubian sandstone. While, on the east side, these beds are tilted steeply, on the west they lie almost horizontal, having

* See Section II.

† See list list of fossils at end of chapter (Wadi Esba).

only a slight dip eastwards. If followed southwards, however, they
Gebel Hadûd. gradually rise higher and higher, culminating in Gebel Hadûd which has a dip of 15° to the south-east, and is let down by the fault above mentioned. It consists of thin-bedded flinty limestone into which a few veins of a glassy basalt have been intruded. To the west and north-west it presents a steep escarpment which is almost entirely covered by blown sand, thus making the descent easy. This is true for the whole of the patch on either side of Seh Baba. Along the side of Wadi Shellâl, and at the mouth of Wadi Baba, the Cretaceous marls are partly visible below the limestone, the other part being carried below ground by the main fault.

The way in which the Miocene is deposited in this basin is somewhat peculiar. Instead of the beds on the west being bent or worn into the form of a trough, as the appearance on the east leads one to expect, they are broken right through and the Miocene * is laid horizontally against the ends. It may be that a fault exists under these younger beds, but there is no conclusive evidence. Crossing the plain of El Markhâ, the plateau on the north side is found to consist on the east of Cretaceous limestone which has been faulted down below the Carboniferous limestone occupying the top of the ridge to the east. Further west near En el Markhâ the limestone ends in an escarpment and the marls appear dipping under the limestone at 7° in a north-easterly direction. Working seawards a sharp fault is met with, by which the limestones are thrown down against the marls and Nubian sandstone; it dies out near the head of Wadi Nokhl. This is in all probability a broken anticline, as the marls are steeply tilted and the sandstone appears high in the cliff. Towards the fault, i.e. north-east, the beds on the downthrow side are dipping at an angle of 16°; while those on the north side of Wadi Nokhl dip 25° to the south-east, this being apparently due to the downward drag produced by the above-mentioned fault. Near the mouth of Wadi Nokhl a dyke of dolerite cuts the limestone in a north-and-south direction, and runs out to sea a little further south. At this point there is scarcely any beach, the limestone escarpment almost touching the water at high tide, while further to the north the water washes the foot of the cliff.

Further to the north, the Cretaceous limestone escarpment bends sharply round at right angles to its previous direction, exposing the marls in a small area which is an anticline, there being a dip of 10°

* See Section VI.

towards the sea in the limestone ; while the marls and eventually the limestones disappear under a beach deposit (Miocene) to the east. The dyke previously mentioned is again seen here and is lost for the present under the beach deposit which contains a contemporaneous lava flow.

Wadi Tayiba.

Further north near the mouth of Wadi Tayiba the marls give place to the limestones, and these are covered by the above-mentioned deposit. Passing up Wadi Tayiba its sides are composed of vertical cliffs of the flinty limestone of the upper Cretaceous which are dipping about 17° towards the sea. The general arrangement of the beds in this area is shown in Section V. From it it is seen that the limestones here reach a thickness of 500 metres, and that only after modifying the dip somewhat, as the general conditions of the district do not warrant the assumption that the dip of 17° is anything but superficial, the inclination rapidly becoming less as the beds pass towards the centre of the trough. The structure of the country here is a combination of two sets of folds, the main one having its axis north-west south-east, parallel to the Gulf of Suez, while that of the other lies more or less east-and-west. The sides of the main fold are much more steeply inclined, while the other has gentler inclinations with consequently wider intervals between the folds. In the main fold, beyond the slight fault which is met with in the hill capped by the Miocene, the dip is 10° towards the sea and 5° away from it. This is not shown in the section as the line passes through a node formed by the two sets. Further up the wadi, the second class of fold shews little or no dip as the wadi happens to be in the centre of the syncline at that point. In the wadi at the foot of the Miocene-capped hill, small cracks in the limestone were found lined with sulphur and gypsum. Further up the wadi the dyke (p. 140) previously mentioned was again met with in Wadi Hamr and continued its course in a north-easterly direction for some distance, but it apparently dies out before it reaches Wadi Ethal as it was not seen there. This dyke is 5 to 6 metres thick and at its junction with the limestone it is tachylitic, while the latter rock has developed hydrocarbons. This is the case with every intrusion into this limestone. Besides this dyke small veins of basaltic rock were met with in two other places in the wadi. As the rocks are crossed in an easterly direction it is seen that they are in descending order until the basal bed (the *Gryphæa vesicularis* limestone) is found on the side of the fault capped by the beach deposits in Gebel Sarbut el Gemel, the general dip being 4° N.W. On the edge of the fault the dip is much steeper, being 40° in the same direction.

On the south side of Wadi Hamr the limestone is seen dipping at 30° towards the fault which has thrown it down against the Carboniferous, while there is a dip of 7° N. W. Nearer the wadi a small patch of marls is seen on the upthrow side of the fault, which is broken by two small faults hading east, and having a throw of about 30 metres each. On the other side of the wadi the limestone shews a dip of 8° to the south-west. Practically the whole of the country on the downthrow side of the fault between Wadis Hamr and Ethal is made up of Cretaceous limestone.

To the north of Sarbut el Gemel the Cretaceous marls have been let down by an offshoot of the main fault against the Nubian sandstone, and tilted at angles of 30° to 40° towards it. Another line of fracture more or less parallel with the other, but which eventually fuses with it, lets down the marls to the west forming a trough-fault, dips of 30° also being seen. Further north the fracture dies away, and the marls rise above the sandstone to their normal position. Following up the boundary between the two, a small patch of the *Gryphœa vesicularis* limestone is found lying against the Nubian sandstone, having been let down by a fault from the plateau above. The marls at Ras Ethal * form a plateau bearing the name of Gebel Abu Dêmat. Here the top members of the series are absent, and the general dip is 5° to 6° E.

In the limestone beds here several kinds of echinids were found as well as ostrea. Associated with the echinid bed is another also full of spines and echinids ; it is highly crystalline and often stained a dark amethyst colour by manganese compounds. To the north of Ras Ethal the marls bend over sharply from the top of El Ti and join those of Abu Dêmat and Gebel Madsûs, the fault which ran along the foot of the cliff having died out.

Gebel el Ti.

The upper half of the cliff of El Ti, from Gebel Dhalâl to this point, is made up of Cretaceous marls ; in the latter hill there is a thickness of 98 metres of these beds, but as they were much crystallized in the more calcareous beds it was difficult to recognise the fossils. The *Nerinœa* which was found in Gebel Qabeliat and other places was seen here. Bauerman † and Le Neve Foster, in their expedition in this district, measured a section further north of which the following is the sequence :—

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* See list of fossils at end of chapter.

† Op. cit. p. 26.

Top.

1.	Limestone and marl, some chloritic and some with flint nodules; a hard bed near top	30·5 metres
2.	Tumbled stuff	15 „
3.	Compact limestone	6 „
4.	Tumbled stuff	12 „
5.	Calcareous sandstone with nodules of alabaster	15 „
6.	Limestone and shales with large *Ammonites*	30·5 „
7.	Hard limestone and shales with rubbly bed containing *Hippurites* with ferruginous sandy bed at top	30·5 „
8.	Hard, compact, cream-coloured limestone	3·75 „
9.	Shales and sandy shales with gypsum, and thin nodular limestone at top	30·5 „
10.	Coarsely-bedded sandstone	6 „
11.	Shaly beds	15 „
	Total	194·75 metres

On the north side of Wadi Ethal the marls slope down from Gebel el Ti at an angle of 5° or so and run to earth at the foot of the limestone escarpment of Gebel Krêr, and continue through Gebel Hiâla up to and beyond Wadi Abu Qâda.

Gebel Krêr.

This hill consists of two ranges on the south side which fuse into one as Wadi Abu Qâda is approached. Its eastern member consists mainly of Lower Libyan limestones laid on the *Gryphœa vesicularis* bed. To the west of this comes a patch of Cretaceous marls let down against the Libyan beds by a fault—the continuation of the main fracture. The Libyan beds dip steeply at first at 40° but this falls rapidly to 8° as the fault is approached. In the marls the dip is at first 5°, but before they disappear under the second ridge of Krêr they take on suddenly an inclination of 15°. Here it was noticed that deeper-water conditions had evidently existed, as shewn by the fusing together of two separate limestone beds, and the exclusion of an intermediary marl, thus giving a limestone of respectable thickness. In this bed many *Cyphosomas*, *Pseudodiademas*, etc., were collected. In the second ridge of Gebel Krêr, at the top of the *Gryphœa vesicularis* bed, a nodular layer was seen in places between it and the overlying Eocene. In Section IV, the general relations of the beds are shewn.

Passing down Wadi Ethâl it is found that the Cretaceous limestone is only represented by the chalky bed which forms its basal member, the upper beds having disappeared. This bed evidently forms a flat syncline in which the Eocene beds were laid down, and from which they had been subsequently eroded before the deposition of the Newer Tertiaries. In this syncline are many patches of shallow-water beach

deposits. In the plain up which the Suez-El Tor telegraph line goes, there occurs a shallow basin in which Beach deposits have been laid down. From underneath these rise up beds which are in all probability Eocene, and pass into the Hammâm-Usêt range which is composed mainly of nummulitic rocks. There is, however, a difficulty in determining the exact boundary between the two rocks, and it is difficult to account for the apparent absence of the great thickness of limestone which was present in Wadi Tayiba. It is likely (although difficult to prove by examination in the neighbourhood of the hot springs which issue from the base of the cliff) that the basal limestones of the Cretaceous constitute the base of the coast-range, and it has been assumed, in the absence of proof to the contrary, to be so. Section IV shews the interpretation of the structure of this range.

Hammam-Usêt Range.

Between Wadi Ethâl and Gharandel, Cretaceous limestone is exposed along the hollows between the ridges of Newer Tertiary deposits. Further up the latter valley, to the east of the gypsum hill of Gebel Gushia, the limestone is the basal bed of the Cretaceous limestone. This limestone also formed the base of Gebel Abiad and the low ground close by, where dips of 12° S.W., and 8° N.W. were seen. To the east of Gebel Abiad the Cretaceous limestone has been carried forward by a dip-fault, and the basal limestone with its overlying Eocene has been thrown down by the main fault to the west. Beyond this the marls have been much disturbed by faults. First, the dip-fault above-mentioned runs along the wadi causing a horizontal displacement; secondly, a strike-fault breaks them parallel to Wadi Wuta thus exposing the Nubian sandstone; and thirdly, another throws down the upper marls to the west; this fracture eventually meets the main line and becomes a part of it. The main cliff of El Ti is composed of the marls of which nearly all the upper members are present.

Country between Wadi Ethâl and Gharandel.

Passing north towards Wadi Bagha, a dyke was found in the marls which has evidently not cut its way through the overlying limestones, as it does not penetrate the entire thickness of the marls.

Behind Gebel Abiad a small patch of the marls is evidently brought up through the limestone by a fold; while the basal member of the Cretaceous limestone forms a sort of setting to the patches of upper Eocene which cap the hills here.

A little distance further north at the end of this hill, it was found that the Cretaceous beds had been replaced by nummulitic limestone and from this point northwards they were not again met with. The marls continue to occupy the cliff of El Ti as far as Gebel Bisher, but are

never seen in the plain. There must have been a considerable amount of overlap during the deposition of the Eocene in this area, as it is found lying on different beds, while, as has been shown in the chapter on the Eocene, nearly the whole series from top to bottom is found within a few kilometres.

Age of the Cretaceous beds.—Concerning the age of the Cretaceous series of the rocks found in Sinai, there seems to be a fairly general consensus of opinion amongst geologists. All are agreed as to the presence of a considerable thickness of Cenomanian beds; but as to the presence of Turonian beds different writers are not in agreement. Rothpletz states that no Turonian exists in Sinai; while the late Dr. Duncan considered that there were grounds for the belief in the presence of these beds.

The presence of Senonian beds is proved by the numbers of *Gryphœa vesicularis* in the white chalky limestone at the base of the mass of flinty limestones about 400 metres thick. Whether these limestones belong entirely to the Senonian, or partly to the Danian also, is impossible to determine, as this great mass of rock is remarkably unfossiliferous.

Gypsumised Cretaceous rocks.—It now remains to describe those rocks which have undergone alteration into gypsum. The first occurrence noted was on the eastern slope of Qabeliat where the Miocene deposits had been removed by denudation. It was evidently a part of the Cretaceous limestone which had been altered. The main patch, however, occurs to the north of Wadi Ferân and forms the floor on which lie the Miocene deposits. It appears in the cliff composed of these rocks which overlooks Wadi Withr. When examined it is seen to consist of a more or less pure bed of gypsum at the top, below which come marly beds having a great resemblance to the Cretaceous marls. Further north, in the northern Wadi Withr, a section of these rocks was seen in Gebel Morr. At the top came the Miocene deposits followed by gypsum, beneath which came gypseous marls, these finally passing into unaltered Cretaceous marls. That this is the work of water seemed undoubted, as the marls are veined in all directions with strings of small crystals of this mineral; while the hard compact limestone beds have been in many places entirely recrystallised, and changed into aggregates of small plates of gypsum. In the report of the Eastern Desert* it was pointed out that the gypsum in that area was closely

* "Topogr. and Geol. of the East. Desert of Egypt, Central Portion." Cairo, 1902, p. 196.

associated with the Beach deposits, and, it was believed, owed its origin to them. In the area under description clear evidence was found proving that the alteration had proceeded from above downwards, for when a section was examined, the gypsumised marls were found to pass into marls containing gypsum, and finally unaltered rocks containing Cretaceous fossils round which were little clusters of gypsum crystals. No further evidence is needed to establish this explanation, and dispose of the theory of gases rising from below as the metamorphosing agent.

These beds occur under the Miocene deposits wherever the latter have been removed, while their unaltered representatives are often seen standing out beyond the area in which the latter have been deposited. To the north of Sêh Sidri they form an irregular triangular patch where the Beach deposits have been removed, and are underlaid by the unaltered marls as in Wadi Withr. At the base of Gebel Hadûd they are cut off by the fault which throws down the Cretaceous limestone and the Miocene deposits.

These beds are the metamorphosed representatives of the *Gryphœa vesicularis* limestone, and the upper half of the Cretaceous marls. In this they differ from those on the western shore of the Gulf of Suez, where in nearly every case the lower limestone of the Eocene was included with the upper member of the Cretaceous.

Although it has been clearly established that the alteration into gypsum is from above by the agency of water, yet there still remain some inexplicable points. For instance, in no single case which came under the writer's observation, where the *Nummulites Gizehensis* bed underlaid the Miocene deposit, was this bed gypsumised. At first it seemed as though different conditions existed in these areas, but this idea was soon disposed of when the Cretaceous and the nummulitic beds were found underlying the younger deposit in one area, where the former were gypsumised, while the latter remained unaltered. Whether it be that the numerous fossils in the latter render it less amenable to the action of water is uncertain; it may be that it allows the water to pass through more easily than the closer and more compact chalky rock of the Cretaceous. Or perhaps the better explanation is that the more finely divided chalky nature of the Cretaceous limestone renders it much more liable to alteration by percolating water, than the more compact, semi-crystalline nummulitic limestone.

FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

Gebel and Wadi Qabeliat.

Nerinæa olisiponensis, Sharpe.
Ostrea (?) *alicula*, Hamlin.
do. *flabellata*, Goldf.
do. *Africana*, Lam. sp.=*O. Auressensis*, Coq.,
O. suborbiculata, Lam. sp.=*O. Mermeti*, Coq.
Plicatula Reynesi, Coq.
Cast like *Glycimeris Marrotianus*, d'Orb. sp.
„ „ *Cucullæa Ligeriensis*, d'Orb.
=*Arca indurata.*
Sphærulites Lefebvrei, Bayle.
Salenia Batnensis, Peron and Gauth.
Hemiaster scutiger, Forbes.
do. *Heberti*, Coq.

Gebel Safariat.

Tylostoma globosum, Sharpe.
Ostrea ? alicula, Hamlin.
do. *Africana* Lam, sp.=*O. Auressenis*, Coq.
do. *suborbiculata*, Lam. sp.=*O. Mermeti*, Coq.
Gryphæa vesiculosa, J. de C. Sow.=*G. Vesicularis* var. *judaica*, Lart.
Sphærulites Lefebvrei, Bayle.
Diplopodia ? variolare, Brong.
Linthia oblonga, d'Orb.
Coptophyma problematicum, Peron and Gauth.

Gebel and Wadi el Araba.

Ostrea like *lignitarum*, Coq.
do. *flabellata*, Goldf.
do. *Olisiponensis*, Sharpe.
do. *Africana*, Lam. sp.
do. *suborbiculata*, Lam.=*O. Mermeti*, Coq.
do. sp.
Gryphæa vesiculosa, J. de C. Sow.
Sphærulites Lefebvrei, Bayle.
? *Diplopodia.*
Linthia oblonga, d'Orb.
Coral like *Thamnastræa decipiens*, Mich.

Wadi Raqqa.

Hemiaster scutiger, Forbes.

Wadi Thaghadi.

Ostrea olisiponensis, Sharpe.
do. *africana*, Lam. sp.
do. *suborbiculata*, Lam. sp.=*O. Mermeti*, Coq.
Sphærulites Lefebvrei, Bayle.
Diplopodia variolare, Brong.

Wadi Esba.

Ostrea olisiponensis, Sharpe.
Plicatula allied to *batnensis*, Coq.
Holectypus excisus, Desor.
Linthia oblonga, d'Orb.
Hemiaster scutiger, Forbes.
do. *Heberti*, Coq.

Nagb and Wadi El Budra.

Ostrea olisiponensis, Sharpe.
do. *africana*, Lam.
do. *suborbiculata*, Lam. sp.
Heterodiadema libycum, Cotteau.

Wadi Ethàl.

Ostrea flabellata, Goldf.
do. *africana*, Lam. sp.
do. *suborbicula*, Lam. sp.
Sphærulites Lefebvrei, Bayle.
Diplopodia ? Sinaicum, Desor.

Wadi Silfa.

Ostrea rediviva, Coq.
Plicatula allied to *batnensis*, Coq.
Linthia oblonga, d'Orb.

Section V.—THE NUBIAN SANDSTONE.

Under this heading are grouped all the rocks which come between the Cretaceous marls and the Carboniferous beds. They consist of a mass of sandstones varying in colour from a dazzling white, through pink and red to dark-brown, and singularly remarkable for the entire absence of fossils in them.

Russeger * described the sandstones occurring in Egypt and Nubia as "Nubian Sandstone," and in his maps of Egypt, Nubia and Arabia

* "Reisen in Unter Aegypt. auf d. Halbinsel d. Sinai &c.," Vol. III.

Petrœa coloured it as Lower Cretaceous. In the text of his book he makes no positive statement, but says that the beds in question are not younger than Lower Cretaceous.

In 1864, Figari Bey * described the sandstones occurring in Egypt, Sinai, and in the neighbourhood of Aqaba. In Sinai he mentions the tripartite arrangement of the series (two sandstones with a thin limestone between them). He assigns a thickness of 850ft. to the sandstone of Aqaba. In Sinai he regards the whole series as being of Triassic age. He considers the limestone as representing the Muschelkalk, although his reason for this determination is not quite clear. Perhaps the resemblance in position of this limestone to the Muschelkalk may have been the reason for the above determination.

Bauerman † in 1868, after his visit to Sinai, adopted the same view, although he states that he has no decided opinion on the subject owing to the great want of evidence.

Hull ‡ describes them from the head of Wadi Hamr right along to Gebel Dhalâl, but, as he includes the Upper sandstone of the Carboniferous under this heading, his boundaries and the writer's necessarily differ.

General Description.

These rocks were first met with in Gebel Hammâm Saidna Musa, where they were capped by a coral reef dipping 8° S. The sandstone dips about 10° S.E. Further north, in the Wadi el Araba, they form a band between the igneous coast-range and the Cretaceous marls, while on the opposite side of El Qâ they are seen forming the floor and part of the sides of Wadi Thaghâdi. Again, at the junction of the sedimentary and igneous rock in Wadi Ferân, they appear and persist right up Wadi Mokateb, ending against the Carboniferous, and sweeping round to Gebel Abu Alaqa, from whence they run northwards as far as Wadi Shellâl, where they are carried down below the surface by the main fault. A small patch is next seen on the north side of El Markhâ, while the main exposure extends from the head of Wadi Ethâl, along the foot and in the cliff of Gebel el Ti as far as Gebel Dhalâl which is the eastern boundary of the area described. North of Wadi Hamr these rocks are seen in the foot of the cliff of El Ti where it is cut out by a fault at Wadi Bagha.

Gebel Hammâm Saidna Musa.

Taking the areas in turn it is now necessary to describe them in detail. In Gebel Hammâm Saidna Musa it is a yellow sandstone covered

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* "Studii scientifici sull' Egitto," etc., Lucca, 1864.

† Op. cit p. 27.

‡ Op. cit p. 31.

by a Beach deposit and dipping 5° S.E. This forms the base of Gebel
Wadi el Araba. Abu Suwêra and is continuous with that which appears in Wadi el Araba. Here the sandstone consists of the following members from above :—.

Top.

1. Red sandstone containing numerous pebbles of quartzite.
2. Purple sandstones.
3. Pure white sandstone.
4. Red or brownish sandstone lying unconformably on igneous rock. These dip at 10° to 15° to the east.

In the wadi, beds of white and pinkish pebbles are met with which are remains of the weathering of the sandstone, while the sand has been piled up on the flank of the igneous range, this being a direct contradiction to Walther's statement as to the origin of the sand. Further north, where the upper part of the wadi enters the sea through a break in the igneous range due to a dip-fault which has thrown forward the coast-range with the sedimentary rock in proportion, some of the white sandstones which occur in the wadi have become so impregnated with hydro-carbons as to be perfectly black, while the smell is very marked. This sandstone continues up to where the igneous range ends, the rest of it being lost under the gravels in the coast plain.

In Wadi Thaghâdi there occurs a patch of dark red Nubian sandstone which seen from a distance, appears like dark-red igneous rock. It was probably this which made Walther mark it "? granit" in the map which accompanies his "Korallen Riffe der Sinaihalbinsel," as he could not have been at all in doubt of the nature of the rock had he visited it.

At Wadi Ferân where the gneiss is cut off by the main fault the Nubian sandstone comes in in a wedge-shaped piece; this is due to the vicinity of a node in the fault, the throw being much less than it is further south. In places it is still lying on the flanks of the gneiss as if it had been dragged down from above by the rocks previous to their being fractured.

Wadi Mokateb. On the north side of this wadi, where the other Wadi Mokateb enters it, the sandstone forms a narrow strip dipping from 5° to 7° west. As the water-parting is reached between the two wadis bearing the name of Mokateb the low hills of the Cretaceous marls suddenly shrink up, the sandstone widening correspondingly ; the former presents an extremely narrow outcrop, due perhaps to a sharp fold, for it opens out again further north. As the sandstone outcrop widened the dip became almost nil ; further north the inclination is slightly towards the gneiss

hills. The character of the rock is very similar to that in the coast-range of El Araba, it being composed of rather coarse sand containing numerous pebbles of quartzite. Near the top it becomes thin-bedded, and fissile, rather approaching a marl in appearance, while its colour is a pale purplish-pink with darker ferruginous bands. Lower down in the series in Wadi Mokateb, where the numerous fine inscriptions occur, the rock is a dense, dark-red and durable one. From the point where Wadi Sidri leaves the hills the sandstone sweeps round towards Gebel Abu Alaqa where its outcrop suddenly narrows, its dip gradually changing to a southerly direction while in the hill itself it is apparently lying horizontal. Here, as was stated in the previous chapter, there is a difficulty about the junction between this rock and the Carboniferous. It may be that there has been a dome-shaped mass such as appears immediately to the north where the rocks are dipping steeply to the southwest, the Carboniferous rocks in the centre appearing on the same level as those stratigraphically above them. There is no doubt that a fault exists between this formation and the hills, as it is impossible for these rocks to overtop them, and become continuous with those on their eastern slopes.

Wadi Budra.—On the north side of Wadi Sidri, the Nubian sandstone is present at the mouth of Wadi Budra as a narrow strip dipping steeply at 25° to the west under the Cretaceous marls, while below it come the Carboniferous rocks. As the wadi is followed up, the dip gradually falls to 10°, the outcrop at the same time becoming relatively wider, but after passing the Naqb Budra and approaching Wadi Shellal, it is suddenly nipped out by a fault. In this particular area the sandstones are not so compact as in other places, the tendency rather being towards thin-bedding and fissility, with a higher percentage of argillaceous matter and iron, the latter in places being so abundant as to make the rocks a dead-black, thus simulating the appearance of basalt. Just a little distance to the north of Maghara a small rhomboidal piece of these rocks has been let down into the Carboniferous beds by a fault, thus causing the turquoise beds to disappear below ground.

On the north side of El Markhâ there is a small patch of Nubian sandstone brought up by a fault in the middle of the Cretaceous area.

Coming now to the main mass of Nubian rocks which are found in the cliff and along the foot of Gebel el Ti extending from lat. 28° 50′ N. to 29° 14′ N., the place where they were examined in detail was in

Gebel Dhalâl. This hill, which is an off-shoot of Gebel el Ti, consists of the following main divisions measured by aneroid :—

Top.

1. Crystalline marly limestone containing small gasteropods and a big *Nerinæa*... ... ... 98 metres
2. Reddish, slightly argillaceous sandstones ... ... 80 „
3. Pure white sandstone forming the base and foot-hills of Dhalâl ... ... 214 „

This white sandstone is of a very dazzling appearance when seen at a distance. It is very friable, strongly false-bedded, and contains a few small lenticles of white quartz pebbles, these being also scattered sporadically through it. On account of its friability it is easily worn away by the wind, and forms steep-sided, rounded knolls which it is dangerous to attempt to climb owing to the readiness with which it crumbles under the foot. Crossing over an area of this rock makes very difficult going for camels, on account of round hollows which have been eddied out by the wind and sand, and also the sudden drops over small waterfalls, etc., which are of frequent occurrence. In this hill are magnificent examples of wind and sand action, the rock being weathered and hollowed out into buttressed scarps of the most fantastic shapes. If this rock were in a more favourable position for transport it would have been a valuable source of sand for the manufacture of glass. Situated as it is the cost of transport would be so great that it would be impossible to make glass from it at a profit.

Following the outcrop of the white sandstone northwards, it seems as it approaches the Wadi Siq, to contract and become lower in the cliff, while the Carboniferous appears to expand correspondingly, this being perhaps due to a roll in the beds. Towards the base of the white sandstone the beds become coarser and more gritty, as if they had been deposited in water not far from land. This has been undoubtedly the case, as the underlying Carboniferous is here very thin, a proximity to land being also suggested by the ripple-marks and false-bedding which are so frequently seen. The reason for the thickening of the Carboniferous is that in going north the observer is going towards the deeper water.

Passing northwards across the Debbet el Ramli the Nubian sandstone occupies the base of El Ti, and extends out into the plain beyond the bed of Wadi Garf. The boundary is here drawn somewhat arbitrarily on account of the amount of blown sand in the plain ; it was only by connecting points where the remains of basalt were seen, or the quartzite bed which underlaid it was noted that this could be done.

SAND ACTION IN GEBEL DHAI AL.

Further west the outcrop of the sandstone narrows considerably, its boundary running up to the foot of the cliff; the reason for this is not clear, but it is most likely due to a change in the dip, combined with a roll in the beds. This narrow outcrop continues until the head of Wadi Hamr is reached (the most northerly limit of the Carboniferous), when it suddenly opens out into a vast terraced plain, the great extension being due to a reduplication of the beds by the prolongation of the Wadi Nasb fault. In this plain, which is practically the last exposure of these sandstones of any importance, the dip is about 5° towards the cliff, with also a gentle inclination westward. Against it, at Sarbût el Gemel, the Cretaceous limestone is let down by the main fault; while farther north the Cretaceous marls are seen lying against this sandstone at an angle varying from 30° to 40°, being thrown down by an offshoot of the main fault. Further north the fault dies away, and the sandstone dips under the marls in the normal way. It has evidently been a trough which was broken by the fault running along the present edge of the cliff, as when the fault dies away a normal syncline is left.

Along the western edge of the plateau of Abu Dêmat the Nubian sandstone is also exposed by a fault which has let down the overlying limestone against it.

In Wadi Abu Qâda the Nubian Sandstone is exposed on one side by a fault which has let down the overlying marls against it. Further north, along the cliff of El Ti near Wadi Bagha, the Nubian Sandstone is again seen, being exposed by a fault which has let down the marls and the Upper Eocene beds against it.

These beds are remarkably constant in their characters over wide areas, as well as in their total thickness. In describing the section at Gebel Dhalâl it was found that the thickness was 294 metres; while in Section VI, where the dip was measured and the outcrop accurately known, it scales out at 300 metres, the two results thus tallying very closely.

Origin of this Sandstone.

About the origin of this deposit there seems to be a difference of opinion. Walther * ascribed it to Aeolian action, and Fourtau † in 1898 reiterates this statement, while the majority of earlier writers regard it as of fluvio-marine origin. (The finding of *Inoceramus Cripsii* at Aswan in these rocks by Dr. Ball supports this view). With the latter idea the writer's views coincide; indeed it is difficult to imagine how

* "Ueb. Ergebn. ein. Forschungsreise auf d. Sinaihalbinsel u. in d. Arab. Wüste." Verhandl. d. Gessel. f. Erdk. z. Berlin, 1888, Bd. XV. N° 6, pp. 244-245.

† Op. cit.

any one could ascribe such an origin as the former to a deposit covering such enormous areas of country. The whole appearance of the rocks is against it; for instead of being a big, unstratified, tumbled mass, as Fourtau says, they are well-bedded, in every place shewing the dip running in a normal fashion. In many places there is strong false-bedding, but that differs in character from the rippling seen in a sand-dune; for whereas in the latter the grains are invariably rounded and highly polished, in the other case they are angular or subangular with a much less degree of polish. The fact that in places there are clayey and marly beds here and there in the series is also against this idea; while the strongest argument against it is the appearance of the sheet of basalt lying between it and the Carboniferous, which has none of the characters of a subaërial flow but has undoubtedly been poured out under water. The latter writer, as well as Walther, includes all the sandstone above the Carboniferous limestone in the Nubian Sandstone, or as he prefers to call it, the Sinaitic sandstone. This being the case, it is difficult to explain the gradual passage between the limestone and sandstone, as also the presence of fossils such as *Lepidodendron*, and the explanation must be left to the supporters of the æolian origin of these rocks.

The age of the Sandstone.

It is difficult to assign a definite age to this mass of sandstones seeing that no fossils have been found in it. Hull * in his map puts it as (?) Neocomian, Cenomanian, and this is undoubtedly correct as far as it goes. It is known that in the marls which overlie this rock a well-known Cenomanian fossil (*Hemiaster cubicus*) occurs. It is therefore probable that the top, at least, of these sandstones is of Cenomanian age, while the other part is Neocomian. No breaks, as far as this formation has been examined, have been noticed, but it is a difficult thing to recognise an unconformability in sandstone where so much false-bedding exists. It is possible that a great thickness of sandstone overlying the lava flow, which is assumed as the upper boundary of the Carboniferous, has been removed during the continental period which undoubtedly existed from Carboniferous to Cretaceous times.

Section VI.—CARBONIFEROUS ROCKS.

These rocks occupy, on the western side of the Sinai Peninsula, a strip of country extending from the watershed at Gebel Dhalâl, along

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* Op. cit.

the foot of El Ti as far as the head of Wadi Hamr, from thence running westward until they are cut off by the great fault which has thrown the Cretaceous down against them, and occupying the country as far south as Maghara, and on either side of Wadi Baba. They consist of a thick series of reddish and brownish sandstones underlaid by a bed of limestone, which in turn is underlaid by a series of dark-red sandstones and shales, these resting on the eroded surface of the grey gneiss which forms the country rock. On its upper surface it appears to pass conformably as far as can be seen into the Nubian sandstone series, which in its upper half is known to be of Cenomanian age, but whether this lower part represents the space of time between this period and the Carboniferous it is difficult, in the complete absence of fossils, to say definitely. The writer is, however, inclined to think that, as there is no definite evidence of continuity in the sedimentation, the thickness of sandstone referred to is all of Cretaceous age.

Russeger * in his maps and papers grouped the whole of the sandstones in Sinai as Lower Cretaceous.

In 1864 Figari Bey † described these rocks and the overlying Nubian sandstone, and assigned them to the Triassic period.

In 1868 Bauerman ‡ visited the peninsula and described the sandstones, etc., lying between the igneous and metamorphic series and the Cretaceous beds. He, however, could not come to any definite conclusion as to the age of these beds, and eventually followed Figari Bey in regarding them as of Triassic age, although he did not feel satisfied with the evidence to hand.

In the following year, the Officers of the Ordnance Survey of Sinai § collected the following fossils from the limestone:—

(S) *Orphis Michelini*, Wadi Nasb.
(S) *Streptorhynchus crenistria*, Phil. Wadi Nasb.
(S) *Spirifer.*
* *Murchisonia*, Wadi Nasb.
* *Eulima.* „ „
(S) *Rhodocrinus and Poteriocrinus*, Wadi Nasb.
* *Lepidodendron Mosaicum*, Salter. „ „
(H) *Sigillaria sp.*, Wadi Mokateb.

(S)=Survey Officers. *=J. Salters's collection described in Q.J.G.S. No. 97. (H)=The Rev F.W. Holland.

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* Op. cit.
† Op. cit.
‡ Op. cit.
§ Op. cit.

In 1883 Hull * visited this place and collected fossils which shewed that the age of the limestone was Lower Carboniferous. He gives the thickness of the bed as 20 feet, but as will be shown later, this is far too little, the reason being that he was dealing with a place where it had been much eroded.

It is to be regretted however that, in the section he gives across Wadis Serabît and Nasb, he has turned it round the wrong way. No compass bearing is given indicating the direction of the beds, but as the dip of the beds is north-easterly it is presumed that the line lies north-east—south-west. Accordingly the Debbet el Ramli which is on the right of the section should be on the left as the plain lies to the east of Serabît.

To the sandstones which underlie this limestone, Hull has proposed the name of the " Desert Sandstone " which may perhaps be allowed to stand, although the writer prefers to group it with the limestone under the head of Carboniferous.

He recognises the fact that there are great variations in thickness of these lower beds owing to the irregularity of the floor, only shallow-water types occurring in these areas. During the survey of this area, the observations made enable the writer to endorse these views, and to add that there is evidence of an overlap as well.

Turning now to the detailed description of the rocks it is proposed to work from above downwards. Beginning with the most easterly extension noticed of these rocks, viz., at the head of Wadi el Akhdar, there is a series of thin, gritty, ripple-marked beds, often strongly current-bedded, and dark-red in colour. Further up these beds became lighter coloured, and in the wadi showed fine concentric bands of alternate red and white, the extreme phase of which was the formation of ferruginous nodules with a core of sandstone. These pass upwards by a sharp transition into a pure white, friable sandstone, which has been regarded as Post-Carboniferous for reasons which will be adduced later.

In Wadi Sheqer the base of this sandstone is seen to consist of a conglomerate of quartzite pebbles about the size of walnuts, which is only a little over a metre thick. This is cemented by silica, and is almost a quartzite, while above it the beds are gritty but gradually becoming finer as they are traced upwards, this being in accordance with the supposition that these beds were deposited in a subsiding area. To the north of Wadi Siq these sandstones are seen in better

* Op. cit., p. 45.

development, in a small hill—Gebel Habîr—where the following succession from above was noted:—

Top.

1. Thin bed of pink siliceous sandstone, (quartzite).
2. Series of redder sandstones.
3. Two thin beds of purplish, fissile sandstones with markings resembling plant-impressions.
4. A whitish sandstone forming the base.

The whole of this section amounted to 144 metres thickness. Further north in Gebel Hameier a cap of olivine basalt covers this sandstone and underneath it comes the thin bed of quartzite noted in the above section. In several other hills beside Habir this bed of quartzite is present thus evidencing the former presence of the basalt.

In the Debbet el Ramli the floor of the plain is almost entirely composed of the quartzite bed which underlies the basalt. On the edge of the Wadi Baba a much-altered dolerite dyke cuts the sandstone, this being the only instance met with where the dyke cuts the sandstone above the limestone. It is stated in the description of the lava-flows that the basalt has been adopted as the upper boundary of the Carboniferous rocks, and this has been found to be a very useful indicator; for where it has been removed, the quartzite bed is always present. The reason for the adoption of this bed as the boundary-line is, that in the sandstones underneath the basalt several specimens of Lepidodendron were found, while above it not a single specimen was met with. This may be regarded by some as a somewhat arbitrary line, but in the absence of a better it has been found to answer the purpose very well, the boundary lines fitting in over long distances.

As to the thickness of this sandstone it has never been seen in a complete section, but in Section VI, where the height of the hills and the dip of the beds were known, it works out at 150 metres which is very near the mark, 144 metres having been noted in Gebel Habîr where the limestone was not exposed. Working from Gebel el Ti towards the hills round Wadi Baba, the upturned edges of the beds are crossed in descending order, until in the neighbourhood of Wadi Malha the limestone bed is found, the dip being about 3° towards El Ti. In Gebel Serabît el Khâdim the whole series of the Carboniferous is crossed as this hill is climbed. It is capped by the same bed of olivine-basalt as was seen in the hill of Hameier. Beneath it come the same sandstones, the limestone following in descending order, and then the lower series of sandstones, the whole, excluding the igneous rocks, being

estimated to be 350 metres thick. From the head of Wadi Malha this rock occupies the whole of the plain of the Debbet el Ramli up to the head of Wadi Hamr. No limestone is seen outcropping in the plain, it having gone under just as the edge is crossed. In the region of Wadi Hamr, there are splendid examples of wind action on these sandstone rocks; they are planed off and rounded to such an extent that one might be excused if they were mistaken for granite knolls in the distance. At this spot, too, they are much impregnated with iron oxide, thus causing them to assume the peculiar slaggy appearance so common in the Nubian sandstone. Except for small outcrops in the sides of the hills, or where it has been let down by faults, this rock is not found in great force in the neighbourhood of Wadi Baba. In this district, the country has a general trend towards the base of Gebel el Ti, the beds having a general dip of about 3° in that direction; while they slope up towards the ridge of El Markhâ, where they have been broken by the great fault which runs up the peninsula more or less parallel to the sea. There is a general fall of the beds to the north, as well as the north-east. In Wadi Nasb the sandstone along with the underlying beds is thrown down by the fault first discovered by Bauerman,* to the extent of 153 metres. Further north the throw is not so great as in this wadi, the two sandstones being laid against each other.

The next place where this rock occurs is between Wadis Shellâl and Sidri, where the ground is entirely occupied by it and the basalt, except where a small patch of Nubian sandstone has been let in by a fault. In this area occur the old workings for turquoise in Wadi Qena. They are about half-way up the cliff in a light-coloured bed of sandstone, while on the top of the hill is the basalt flow previously mentioned.

The boundary of this sandstone has been drawn arbitrarily to the south as there is no well-marked line between it and the Nubian series. The main reasons for doing so, are:—

1. *Lepidodendron* remains were found in the rock to the north of the boundary while none were seen to the south.
2. These beds were on a lower level than the basalt.
3. True Nubian sandstone overlies them in Gebel Abu Alaqa.

On their southern border, however, there is a difficulty about the suddenness with which they go under the Nubian. This is capable of two explanations viz: (1) A fault may have let them down, or a sudden change of dip such as is seen on the side of Wadi Budra; or (2)

* Op. cit.

there may have been an overlap of the younger over the older beds. There is little doubt, however, as to the relative age of the beds on either side of Wadi Sidri, and the boundary cannot be far from the actual junction.

In Wadi Qenaia, a tributary of Qena the turquoise-bearing bed runs quickly to earth and does not show again for a good distance to the north, being let down by a fault as well as by a syncline. This fault which is roughly quadrilateral in outline has let in a small patch of Nubian sandstone undoubtedly carrying down the basalt bed with it, thus accounting for the hiatus in the continuity of the flow which could not otherwise be explained. The whole of this area has been much folded and faulted. Towards the west the hills dip steeply about 12°, while northwards they are inclined 5°. On the east side they have been let down by the main fault against the granite, the throw being 990 metres. Step-faulting has also been common as slickensides are very abundant. Some of the sandstones in this district are highly charged with iron, being so dark-coloured as to simulate the appearance of the basalt.

On the north along the side of Wadi Shellâl these beds have been let down again by the same fault, which there bends round in a south-westerly direction, the sandstone which is seen at the top of the hill on the opposite side of the wadi being found in its floor.

In Wadi Budra near its mouth these beds are dipping at 25° under the Nubian sandstone, while only a little distance to the east of this point the beds are horizontal; it seems therefore that here is the remainder of a large anticline which has been broken at its eastern limb while the other has been left intact. Further north the dip gradually falls to 10°, the outcrop of the Nubian sandstone relatively widening.

Along the side of Wadi Shellâl, near where it enters Wadi Baba, and on the line of the main fault, the sandstone has been carried underground, but as the wadi is followed southwards, first Nubian sandstone, then the upper sandstone of the Carboniferous, and finally the limestone appears as the downthrow gradually lessens, until as the branch-fault is followed up, it dies out altogether, the beds assuming their normal position relative to each other.

Carboniferous limestone.—This bed is exposed over an area on either side of Wadi Baba measuring 14 by 16 kilometres. It does not actually cover this area but its various outcrops are met with in it, while several large patches actually exist. It was first met at the head of Wadi Malha where the guide had taken the writer to show him a curious black stone

which had excited his curiosity, and which turned out to be a mixture of pyrolusite, psilomelane and hæmatite. After examination, this ore was found to lie in pockets at the base of a dark, crystalline limestone, at its junction with the underlying sandstone. These pockets were from ·7 to 1·3 metres deep. (For a fuller account of this ore see section on Economic Products, p. 199). This bed of limestone was traced over the plateau to where the true Wadi Baba begins, a distance of 6 kilometres. In places the limestone is highly impregnated with manganese ores. In the middle of this bed there occurs an ochreous, fissile limestone, which has been worked round the edges of the small knolls on the plateau for copper; numerous workings were seen, but no galleries or tunnels were met with. From what could be seen, the ore (which was malachite) was only in incrustations on the sides of cracks and did not look at all worth working. There seems to be little doubt that this was one of the places whence the ancient Egyptians got the ore which they smelted in Wadi Nasb.

Wadi Meringa.

As it was the hard crystalline bed which forms the base of this series which covered the plateau above referred to, it was difficult to find fossils in it, but near the head of Wadi Meringa a section was found which shewed it to be composed of:—

Top.

1. Bed of crystalline limestone.
2. Layers of fissile, ochreous limestone.
3. Bed of crystalline limestone.

These were in all from 20 to 30 metres thick. In the ochreous beds were found *Zaphrentis*, *Chætetes*, *Spirifer* and *Productus*, thus shewing that it belonged to the Carboniferous period. This limestone also occurs in Gebel Serabît el Khâdim and the hill to the north; in the former it extends for several kilometres on the surface of the plateau to the south-west. From the former hill a beautiful specimen of kidney ore was obtained, while numerous other examples were seen embedded in the rock. In the ridge separating Wadi Lahiân from Wadi Nasb, this bed also occurs, forming the surface and disappearing under the sandstone which forms Gebel Riglên. On the top of the ridge there are 12 to 15 metres of a dark crystalline limestone containing rounded quartz-grains, and highly coloured by iron ores. At this place, wherever the limestone has been removed, the manganese ores are seen, and doubtless they occur beneath it over all the area. Near the junction of the limestone and underlying sandstone, small pockets of very pure hæmatite occur, varying from 3 to 6 kilos. in weight. Along this valley runs the fault first discovered by Bauerman, which throws down

the limestone against the fundamental gneiss, the throw being 153 metres. According to Hull * the throw is 123 metres; the discrepancy may be due to the different places at which the throw was measured. On the west side of the wadi, i.e., on the down-throw side, there occur, at the base of the limestone, some pockets of manganese and iron ores, and here there was a gallery driven into the rock to work it. At this point are the following members of the series :—

Top.

1 Limestone full of crinoid stems and a few crinoids.
2. „ with *Spirifer* and *Productus*.
3. „ with *Chætetes*.
4. Hard, brittle, crystalline limestone.
5. Ochreous, marly beds.
6. Gritty, crystalline limestone.

These were so placed that it was impossible to obtain the thickness of the various beds. The limestone dips east at this point at 5°, the high dip being due to the fault, but there is also a gentle roll north and south, while the rocks dip N.N.W. at 3°. The basal limestone is often so impregnated by the ores of manganese and iron that it becomes black and brown. The *Chætetes* and brachiopod beds are somewhat fissile but crystalline, while the crinoid bed is a hard crystalline rock.

On the north side of Wadi Baba near the mouth of Nasb there is a good example of the solution of limestone at the junction of these beds with the sandstone.

The fault which throws down the limestone here was traced beyond Wadi Baba to the Debbet el Ramli where further evidence of it was hidden under the sand of the plain.

In Wadi Halliq there are some old mines in the limestone in which manganese and iron ores occur in large quantity, the former largely in the form of wad. It was not for these ores, however, that these mines were opened, as they have been thrown out into the rubble-heaps; the probability is that it was copper, seeing it was the centre of the copper smelting district. To the south of this point the limestone occupies the surface of the plateau—a large patch 7·5 by 3·5 kilometres in extent, and stretching almost up to the granite hills at the head of Wadi Shellâl. Wherever examined, the manganese and iron ores were always found under the limestone.

To the west of Wadi Halliq the limestone occupies the surface of

* Op. cit.

the plateau and extends to the edge of the scarp which overlooks the Cretaceous country to the north of El Markhâ, covering an area 7.5 by 5 kilometres.

On the south side of Wadi Baba, on the range between it and Wadi Shellâl, this limestone is found lying at three different levels, due to a series of step-faults culminating in the main-fault line which runs along the bed of the latter wadi, some of them throwing down over 60 metres.

In places near the edge of Baba the limestone forms a steep ridge often not more than 2 metres wide underlaid by the sandstone, and that in turn by the granite. There are two main step faults which throw down the limestone, and these in both instances have formed drainages which end in sheer cliffs before the water reaches the main wadi. In one of the detached pieces of the limestone a good section was found where it was possible to measure the thickness of the beds, the following being the details:—

Top.

1. Crystalline limestone with thin bed of grit near the top, the whole representing the first four beds in the Nash Section 15 metres
2. Ochreous Marly beds ... ... 9 „
3. Crystalline limestone ... ... 12 „

From the upper beds were collected many corals (*Zaphrentidæ*) *Crinoid* stems, and *Bryozoa*. In Wadi Shellâl the limestone is again seen. From this exposure Walther collected *Crinoid* stems, *Chætetes* and *Zaphrentis*. In 1893 Rothpletz* published a paper on Sinai in which he concludes from the fossils he collected in Wadi Shellâl that these beds were of Permian age. Further up the wadi a dolerite dyke cuts this bed but does not reach the surface.

A comparison of this exposure of Carboniferous limestone with that described by Walther from the Wadi Araba on the west side of the Gulf of Suez, shews the latter to be much thicker and apparently of a deeper water facies as it is richer in brachiopoda, pelecypoda and gastropoda, while in corals only two specimens were obtained; the former on the contrary is richest in corals, and has not yielded any pelecypoda or gastropoda. In thickness that of Wadi Araba is three times that of the Sinai representative. When the thickness of the sandstones above the limestone come to be compared the opposite is the case to what it was with the limestones; for, whereas, Walther only gets 250 metres between the Cretaceous and the Carboniferous, in Sinai there are 150 metres Carboniferous sandstone, and 300 metres more between it and

* "Stratigraphische von der Sinaihalbinsel" (Neues Jahrb. f. Miner, etc. 1893, Bd. I, pp. 101-104).

the Cretaceous limestones, making in all 450 metres. It would thus seem as though shallower water conditions had prevailed in Sinai, sandstone being deposited there, while limestone was forming in Wadi Araba.

The Lower sandstone.—This rock appears underneath the limestone wherever that bed outcrops on the surface. It was first seen in Gebel Serabît el Khâdim, where it consists of a mixture of reddish brown, purple and red shales and sandstones, not so massive and hard as the upper series. In its upper members it is lighter in colour, and in this mountain the ancient Egyptians had worked it for turquoise. The character ascribed to it by Hull, "often conglomeratic or brecciated," was not apparent in Wadi Serabît or Nasb, its composition rather suggesting deeper water conditions than obtained in the upper sandstone. With the thickness given by Hull for this series in Wadi Nasb the writer cannot agree, as in measuring the throw of the fault in that valley the displacement was found to be 153 metres, in which only 15 metres of metamorphic rock were visible. It thus follows that the thickness of the sandstone is 138 metres, and not 46 to 76 metres, as stated by Hull.

At its junction with the overlying limestone it is much impregnated with the oxides of iron and manganese, pockets of these ores, as previously stated, occurring there. No fossils have been obtained from it. As its characters are fairly constant, although occurring over a fairly wide area, no more description is necessary. That it has had a much wider extension in earlier times is certain, as evidenced by its capping the highest hill in the vicinity. It therefore seems probable that it extended a greater distance south in earlier times than at the present day. Before leaving this formation it is necessary to shew the evidence for the overlap which was mentioned at the beginning of this account (p. 156). It was stated that there was a considerable thinning of the Carboniferous beds, as here defined, towards the central watershed, the beds there present representing the upper sandstone. As this formation was followed north and west the sandstone thickened, older and older beds coming in underneath as the old planed-down floor was descended until the limestone beds were found. It would therefore seem that there had been a basin of deepish water extending round by Serabît and Wadi Baba district, in which the water was sufficiently clear to allow of the growth of the crinoids and corals found in the limestone. During the deposition of the limestone, the land which occupied the district of the present central watershed was still above water, but was slowly subsiding, and it was not until after the close

of the limestone deposition, that sandstone and conglomerate began to be formed. It is now necessary to point out a mistake published by Hull in the map which accompanies his memoir, in which he shews his " Desert Sandstone " and limestone to extend in a broad band over the watershed. As this writer has expressly limited the above title to the sandstone underlying the limestone, it is evident from the foregoing remarks that neither of these beds exist there, only the upper sandstone which he classes with the Nubian sandstone being present.

After the close of the limestone period, shallower water conditions seem to have set in. Of this there is evidence in the gritty bed in the upper part of the limestone, and these conditions seem to have persisted after the continental period until about the beginning of Senonian times when a gradual deepening of the water set in, marls followed by limestone being deposited.

As to the age of the lower sandstone some have proposed to regard it as Devonian ; but as there is no sign of fossils to prove this, and in the absence of any unconformity between it and the overlying limestone, it is preferred to regard it as belonging to the Lower Carboniferous.

A short résumé of the main points to be noted with reference to the Carboniferous beds can now be given :—

1. The Carboniferous consists of two sandstones, an upper and a lower, separated by a limestone, its upper boundary being marked by a contemporaneous basalt-flow.

2. It has been deposited on the planed-down surface of the gneiss and schist.

3. Towards the central watershed, there is considerable thinning and overlap, the limestone being confined to the deeper water which existed to the west and north.

4. At the junction between the limestone and lower sandstone, pockets of rich manganese and iron ores exist.

5. This formation has undergone a good deal of faulting, being let down by a series of steps until it lies at the foot of the hill-range with the Cretaceous rocks lying against it.

FOSSILS

DETERMINED BY R.B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

Wadi Meringa.

Spirifer striatus, Martin.
Do „ „ var. *attenuatus,* J. de C. Sowerby.
Reticularia lineata, Martin sp.
Orthotetes? Crenistria, Phillips sp.
Stenopora sp.
Zaphrentis sp. like *Beyrichi,* Rothp.
Do. allied to *Guerangeri,* E. and H.
Syringopora like *ramulosa,* Goldf.

Wadi Nasb.

Spirifer convolutus, Phillips.
Do. tringonalis, Martin ? var, *crassus,* Koninck.
Productus? scabriculus, Martin.
Syringopora like *ramulosa,* Goldf.

Wadi Baba.

Stenopora sp.
Zaphrentis sp. like *Beyrichi,* Rothp.
Syringopora like *ramulosa,* Goldf.

Gebel Abu Alaqa.

Lepidodendron Mosaicum, Salter.

SECTION VII.—TECTONIC GEOLOGY OF WESTERN SINAI.

Much has been written on this subject by various writers such as Suess, Walther, Bauerman, Hull, and Rothpletz, by whom the structure of this area, and the origin of the Gulf of Suez, have been fairly well worked out. Of the work of the various observers an excellent compilation has been published by Blanckenhorn,* who, although he had only visited a small part of this district, has made some very shrewd deductions from the maps at his disposal, in some cases arriving at a more correct conclusion than the author of the map. Thus he points out (what is apparent to any one who has visited the district) that

* "Die Strukturlinen Syriens und des Roten Meeres" von Richtofen Festschrift. 1893.

Walther's sections across Qâ Plain do not represent the structure of the country and suggests a fault along the western edge of the plateau to the east of the plain, which is the true interpretation. (See section I.) In his continuation of this fault-line, however, he runs wrong, as it dies out in the vicinity of Wadi Ferân, whereas he connects it with the Gebel Withr fault which begins in this wadi some distance to the west. In his map this writer shows the main-fault running down to Ras Mohammed; but he errs in making the Qâ fault a continuation of it, the latter being a secondary fracture parallel to the former, which runs along the foot of Gebel Serbâl between the sedimentary and igneous rocks. The coast-line fault he draws only as far as the mouth of Wadi Sidri, where he bends it round inland in the direction of Wadi Shellâl making it cut off the Withr fault. In this the writer does not agree with him, as he has traced the coast-fault up to and beyond Gebel Hammâm Farûn, from whence it is continued up as far as Gebel Atâqa where it fuses with the fault which runs along the north side of that range. Of the tectonics of the district to the north of El Markhâ, Blanckenhorn has not been able to collect any information and has nothing to add on the subject. In the following pages therefore it is hoped to throw a good deal of light on the structure of this district and to add some new facts to those already known about this area.

The tectonic geology of this area may be treated under the following heads:—

1. Folds.
2. Faults, divided into Strike-Faults, Step-Faults, Dip-Faults and Trough-Faults.
3. Rifts.

Folds.—In Western Sinai two sets of folds are recognisable, the dominant one having its axis lying roughly north-west–south-east parallel to the Gulf of Suez, with a fairly steep dip on either side of the trough, while the axis of the other lies more or less at right angles to the first, and has a much more gentle inclination with its saddles further apart. The dominant set has in every case been broken by faults, which has complicated matters considerably, and caused many observers to arrive at a wrong interpretation of the facts. Describing the folds in detail, the first to be considered is that which has given rise to Qâ Plain with the El Araba range on the west and the sedimentary area composed of Gebels Safaria, Asfar, Thaghadi, Wagraf, El Rigma and Asl or Asfa. As was stated in the chapter on the Cretaceous (p.129) Walther and Fourtau fell into the mistake of supposing that this was a normal fold undis-

turbed by faulting, whereas it will be shown that the syncline has been broken by a line of fracture which has thrown the eastern limb far underground. On the east side the beds lie with a gentle inclination of 5° or so to the west, complicated by small puckerings, in which, on the extreme eastern boundary, the dip is very steep on the line of main fracture, at first away from the fault where a sharp V-shaped fold exists, but further on towards the fault, the fracture taking place in the saddle in this case and not in the trough. As stated previously the western limb is formed of Gebel el Araba, and this has not escaped deformation by faulting either, as a glance at the map will shew, the northern half of the range being reduplicated by step-faults. A glance at Section I will shew the relation of the two limbs of the trough after their displacement by faulting. On the west side there is a fair thickness of Miocene limestone which is absent on the east, apparently inclined at 12° to the east, while the underlying Eocene and Cretaceous have a dip of about 22°, which if it be constant would carry these beds far underground. There is no doubt that a fairly big displacement has taken place, as the Cretaceous limestone on the east has been dragged into an almost vertical position before it broke. The corresponding saddle on the west is represented by the igneous coast range on the north and the ridge of Hammam Saidna Musa and Abu Suwêra, the former of which has lost its cap of sedimentary rock, while the syncline, which in an undisturbed state would have formed the Gulf of Suez, has been broken in its eastern limb as in the previous case, thus producing deep water close in-shore. This fold is continued north beyond the Wadi Ferân where it is broken by two faults hading west, in addition to the main fracture along the edge of the hills. Gebel Withr, which forms the western limb, has been broken by one of the faults, while the low ridge connecting Gebel Mokateb with Abu Alaqa is the result of the other. The idea of a trough is not at first apparent, as it has been filled up with Miocene deposits ; but detailed examination proves it to be so. Section III shews the interpretation of this area.

Beyond Wadi Sidri the synclinal arrangement of the beds is not again apparent until the range of Usêt-Hammam Farûn is reached, some other agency having evidently been at work destroying the continuity of the general line of fold. It may be that at this point there exists a node formed by the crossing of the two sets of folds, which, if it be so, would explain the anomaly. After Wadi Hamr is reached the eastern limb of the trough again becomes apparent, although there is no sign of its corresponding western part, the beds seemingly lying in an uniclinal fold. As soon as Wadi Ethâl is passed, however, the

two limbs appear again and form a regular trough in which lie Newer Tertiary deposits ; while the saddles on either side are broken by lines of fault. Beyond Wadi Gharandel up to near Suez the rocks seem to lie in a uniclinal fold, as they dip westward from the cliff of El Ti and never reappear again.

In the case of the second set of folds, as was stated previously it is not nearly so pronounced as the first. It was first noticed at Wadi Ferân where the beds were seen to dip gently on either side of the valley, and it is to this fold that the change of direction of this drainage is due and not to a fault as stated by Walther. The next fold occurs on either side of Wadi Sidri where the marls and gypsum roll gently and cause the south-westerly trend of the drainage.

A south-west-north-east fold in all probability existed where the plain of El Markhâ now is, but being broken by the fault running along the north-east limit of the plain it cannot be recognised, although the inclination of the beds on the north in a southerly direction, and the sudden shift in the direction of the drainage of Wadi Baba point to this conclusion. The next fold is seen in Wadi Hamr and Wadi Tayiba, where the long, gentle slope northwards from the heights to the south is well seen, the drainage following the lowest part of the trough. The fold is not so evident as those to the south, being complicated by the main line of fold which is here again beginning to show. At the mouth of Wadi Tayiba, however, no fold is present; and its direction has evidently been determined by a line of rift or a crack in the flinty limestones of the Cretaceous. The last of the minor folds is found in Wadi Gharandel and its continuation—Wadi Abu Qâda—where the last indications of this flexure are visible in the Eocene and Cretaceous as they are exposed from under the Newer Tertiaries.

Faults.—These are divided into strike-faults, step-faults, dip-faults and trough-faults. Taking the most important first, viz., strike-faults, under this heading is included the great fault which has let down the whole of the coastal region of Western Sinai against the central igneous mass, as well as the secondary fractures more or less parallel with it and the Gulf of Suez, which might be regarded as step-faults if they were closer together. Commencing with the main fault, the first place it was met with was on the east side of the inlier of Gebel Safariat where it was clearly shewn. This fault extends to Ras Mohammed ; although no direct evidence was seen its existence has been inferred. From Gebel Safariat this fracture runs along the foot of the igneous range to Gebel Asfar, Wadi Raqqa being formed along its line, while it

follows the edge of the hills closely, the whole of the Cretaceous and the overlying Eocene being let down below the level of the granite and gneiss hills. Further north, as Wadi Ferân is approached, the Cretaceous limestone, marls, and finally the Nubian sandstone appear on the flanks of the gneiss hills, thus pointing to a diminution of the throw, although this is more apparent than real, as the overlying rocks have been carried away by a side drainage, and if replaced would continue the plateau as seen to the south. Crossing the valley of Ferân with its shallow syncline, this fault is continued along the foot of the hills, the Nubian sandstone only being present, and this continues until Wadi Sidri is crossed, when the Carboniferous sandstone is met with. Here an increase in throw takes place, the lower part of this series lying on the top of Gebel Atâtar el Dhami while the upper part lies at the foot. In places the basalt, which has been adopted as the top of the Carboniferous, lies against the granite which rises from it in a sheer wall and runs as a narrow ridge between the faulted and normally placed sandstones as far as Wadi Shellâl, likewise occupying its north side for some distance. At Wadi Shellâl, for some reason which is not apparent, this fault suddenly changes its direction to S.W.-N.E., the wadi evidently following its line for a time, while short step-faults between Wadi Baba and this valley running more or less parallel to the original line of main fault are cut off by it. From the point where the Shellâl drainage bends round to the north-west to meet that of Baba the main fault returns to its original direction, the former valley and it being coincident; while it may also be regarded as the last of the series of step-faults by which the Carboniferous rocks have been thrown below ground at this place. At this point also, it is joined by the fault which is the continuation of the Gebel Withr fracture. Round the junction of Shellâl and Baba drainages the Cretaceous beds (part of which are only visible) are tilted at 60° to the west, a fairly great throw having taken place, (see Section VI). From the mouth of Wadi Baba the fault-line passes between the sedimentary patch and the gneiss range of Gebel Samra, crosses the edge of El Markhâ plain in a northerly direction, and lets down the big mass of Cretaceous rocks which lies to the north of the plain, below the level of the base of the Carboniferous sandstone; while as it is followed north the throw gradually lessens until at Wadi Hamr the Cretaceous limestone is resting against the Nubian sandstone. Here the Tertiary rocks of Sarbût el Gemel cap the lower member of the Cretaceous limestone. Passing north towards Wadi Ethâl the basal limestone of the Cretaceous (*Gryphæa vesicularis* bed) is seen to be thrown down against the Nubian sandstone in the plateau of Gebel Abu Demat. On crossing this wadi

it is found that the hade has changed to the east, the Eocene rocks being let down against the Cretaceous marls. This is an anomaly which is not easily accounted for, unless it be that the dip-fault which exists in Wadi Ethâl has influenced the main fracture and caused it to alter its hade. The other alternative of an inverted fault does not seem to be possible as there is no evidence on which to base such a theory. It seems rather to be connected with the dip-faults; for in Wadi Abu Qâda, where another of these fractures is met with the hade again returns to its normal westerly direction. From this place the line is north-east and 8 kilometres further on it is joined by a secondary line of fault which lets down the Cretaceous marls at the foot of El Ti, while 3 kilometres further another parallel fracture to the east is cut off by this main fault, which here throws down the Bartonian against the Cretaceous marls. Followed northwards the Middle Eocene is seen to be let down against the Nubian sandstone near the Wadi Bagha. Beyond this valley the fault seems to die out and be replaced by a fold as the Middle Eocene gradually rises up over the marls on which it apparently lies unconformably.

Throw.—The amount of displacement along this line of fracture is not always easy to estimate, as sections are seldom available for this purpose. It may be taken for granted, however, that the sedimentary rocks, (the Carboniferous, Nubian sandstone, etc.,) covered the whole of the hills of the Sinai Peninsula. In support of this view it may be pointed out that even if it be assumed that the dip of the older beds was gradually lessening, they would easily overtop Gebel Serbâl and even Gebel Um Shomer; the similarity of the beds in El Ti, and those on the west side of the hills, the presence of Carboniferous rocks faulted down, and eventually the continuity of the beds to the north, all go to prove the above assumption. Leaving out of count the Carboniferous of which none has been discovered above ground south of Wadi Ferân, and taking the base of the Nubian sandstone as the starting point of calculation which is nearly 300 metres below ground at Gebel Asfar, the throw here is 1770 metres. Again at the foot of the range of which Atâtar el Dhami is a peak, a displacement has taken place of 1320 metres; while at the junction of Wadis Shellâl and Baba there is a throw of at least 1030 metres. Further north the mass of Cretaceous lying to the north of El Markhâ has been let down 1320 metres. Beyond this the throw becomes less and less until the fault dies out.

Secondary faults.—The first of these is met with, as in the case of the main fault, at Gebel Safariat, and is continued up to the east side of Qâ plain, having broken the syncline and thrown down the Eocene and Cretaceous rocks far beneath the surface of the ground. This fault has caused a steep tilting of the beds on its upthrow side and dies out as it nears Wadi Ferân. In Gebel Safariat itself, one or two small faults occur hading west, by which the Cretaceous limestone is let down against the marls; these run in a northerly direction. At right angles to them are two others which reduplicate the marls. Parallel to the line of fracture which runs up the east of Qâ plain is another which runs behind the limestone hills, but hades to the east, this is, however, a fault of no importance. A small fault also occurs on the west of Wadis Thaghadi and Abu Gurdi by which the Eocene is let down against the Cretaceous marls to the east.

Further north on the side of Ferân two more faults occur hading east, part of them being concerned in a trough-fault. The more westerly of the two throws down the Cretaceous limestone against the marls; while the other lets down the Eocene and Cretaceous limestone partly against the marls, and partly against the *Gryphœa vesicularis* bed. The former of the two crosses the wadi and reduplicates the marls, dying out about the head of Wadi Mokateb.

On the other side of Qâ plain in the El Araba range, several faults occur in its northern half; but all belong to the class of Step-faults, except one which reduplicates the outcrop of the Miocene and hades west. Passing on to Gebel Qabeliat a fault is found running along its seaward side by which the Cretaceous and nummulitic rocks are thrown down against the Nubian sandstone and marls. This is continued across the Wadi Ferân and throws down the Eocene of Khadêd el Dhib and the Beach deposits against the Cretaceous marls, and continues north as far as the mouth of Wadi Sidri where it bends inland to join the main fault at Wadi Shellâl. There is another fracture to the east of this and parallel to it, which is designated the Gebel Withr fault, and begins on Gebel Withr. the north side of Ferân, throwing down the Cretaceous limestone of this range against the gypsumised marls of this formation, and joining the western fault at the mouth of Wadi Sidri. On the other side of the Miocene area there is another line of fracture by which the Cretaceous and Eocene limestones are thrown down to the west against the marls, while to the north the Miocene of Gebel Abu Alaqa is let down against the marls and Nubian sandstone. To the east of this hill a small fault hading east throws down the Carboniferous sandstone. (Section III shews the relation of these faults to each other.)

On the north side of Wadi Sidri a small fault lets down the Sandstone to the east; connected with this are two short faults hading towards each other and more or less at right angles to the first, which let a patch of Nubian sandstone into the Carboniferous.

Gebel Markhâ. To the north of El Markhâ in Gebel Markhâ another small fault is seen, by which the Cretaceous limestone is thrown down to the west against the Nubian sandstone.

Wadi Tayiba. On the south side of Wadi Tayiba there is a small fault by which the flint conglomerate with interbedded lava has been let down to the east against the Cretaceous limestone.

Wadi Nasb. Further to the east in Wadi Nasb a fault hading west throws down the Carboniferous limestone below the base of the underlying sandstone, a distance of 150 metres. This fault at its origin to the south takes part in a trough-fault by which a patch of basalt is let into the Carboniferous. It runs in a north-westerly direction across the Debbet el Ramli until it strikes the cliff of El Ti at Gebel Agrab, where it throws down the Nubian sandstone, and further north just before it dies out, the *Gryphœa vesicularis* bed against the sandstone.

Further north in Wadi Wûta a small fault lets down the Cretaceous marls to the east against the Nubian sandstone. Further east on the other side of the dip-fault which follows the Wadi Abu Qâda, two parallel faults hading west reduplicate the marls, and are finally cut off by the main fault.

Gebel Abiad. To the west of Gebel Abiad and Sanafa, a fault bearing N.E. and N.W. has reduplicated the Middle Eocene, in places bringing it against the Cretaceous limestone.

At the mouth of Wadi Usêt a fault has thrown down the limestone in Hammam Farûn thus producing a low secondary ridge on the sea coast.

In Gebel Dhalâl in El Ti, a small strike-fault lets down the Cretaceous marls against the Nubian sandstone.

Step-faults.—Following the rule in the previous descriptions of starting from the south, the first to be noticed are those occurring to

Gebel el Araba. the north of the dip-fault in Gebel el Araba. Here the Eocene limestone was found at four different levels thus indicating 3 step-faults, of which the displacements are as follows:—between the most westerly and the next, 48 metres; between this and the next 30 metres; while between the last and the cliff there was 102 metres. These faults must have taken place after the deposition of the Miocene, as it has been carried down by them.

The next place where these are met with is at the mouth of Wadi Baba in Gebel Baba, where the Carboniferous limestone which occupies the top of the ridge is let down by three steps, the main fault being regarded as the third, until it is found in the bed of Wadi Shellâl. Parallel with these is another which brings down the Nubian sandstone and cuts off the Carboniferous limestone in Wadi Malagan, a tributary of Wadi Shellâl. Gebel Baba.

Dip-faults.—The first to be noticed is that which runs along the south end of Gebel Hammâm Saidna Musa up which the warm springs rise. Although no external evidence exists to prove this fault, still it may be deduced first, from the fact that a line of warm springs rises at the foot of the ridge, and second, the sudden ending of a hill range in a steep escarpment on a flat level plain, which is not the work of denudation.

The next, which is a typical instance of a fault of this kind, occurs half-way up Gebel el Araba, where the coast range of igneous hills is breached by Wadi el Araba. Here the outcrop of the beds is shifted 3·5 kilometres to the west, while the beds are tilted, twisted, and torn in a wonderful manner.

On the east side of Qâ plain and to the south of Gebel Asfa, a fault occurs which by direction belongs to this category, but behaves more like a strike-fault, in that it throws down one bed against another without any shift in the outcrop.

In Wadi Ethâl near its head, a short fault occurs which brings the Nubian sandstone against the Cretaceous limestone, and also changes the hade of the main fault. Further north in Wadi Abu Qâda, another fault has shifted the outcrop of the beds one kilometre to the west, at the same time bringing the hade of the main fault back to the west. On either side of this fault the strike-faults hade in opposite directions thus showing that they were produced concurrently, for had one been prior to the other, the hade of the latter would have been in the same direction right through, there being no disturbing influence to cause a change. Wadi Ethâl.

Trough-faults.—Very few of this kind of fracture occur in this area. The first occurs in Gebel Maghara where a patch of Nubian sandstone is let into the Carboniferous thus cutting out the turquoise-bearing beds.

To the north of this last patch, an area of basalt has been let into the Carboniferous, the Wadi Nasb fault acting as one of the components of the fracture, while another forms a "V" with it and produces the fault, (see section VI.)

Rift valleys.—The only line of valleys which can be safely attributed to "rift" is that which, commencing to the north of Wadi Baba, passes through Wadi Suwiq, over the parting into Wadi Khamîla, across Wadi Siq up Wadi Barq into Wadi Lebwa and Barra, across Wadi el Akhdar, through Wadi Solêf into El Sheikh, up Wadi Sahab and across the plateau to Naqb el Hawa into El Raha near Gebel Musa. This is a remarkable line of valleys which it would be difficult to explain otherwise seeing that it lies parallel to the Gulf of Suez and in all probability owes its origin to the same causes. Another remarkable line which lies fairly parallel with the first is that which, commencing at Wadi Siq, runs up the Wadi Entish and Shêqer, through Wadi Hemeier and Harqus, across the plateau to El Watia where it enters El Sheikh which it follows to its head.

M. Raboisson * has called attention to the peculiar network arrangement of the valleys in Western Sinai. These lines of rifts are accountable for some of those lying N.W.-S.E.; while the lines of fold give rise to the others. The east and west drainages generally are formed along lines of east-and-west folds; while for the S.W.-N.E. drainages it is difficult to give any explanation, unless it is that they are lines of weakness parallel to the rifts on the eastern side of the peninsula and produced by the same forces which have been at work there.

The age of the rift of the Gulf of Suez.—This has been discussed to a certain extent in the "Report on the Topograghy and Geology of the Eastern Desert of Egypt, 1902, p. 214, in the chapter devoted to "Faults and Folding." In it the probable course of the coast-line fault on the Sinai side has been sketched out, and the age of the rift discussed as far as could be done with the information then available. To recapitulate. Blanckenhorn † following Neumayr, assigns the age of Middle Pliocene to the formation of the Red Sea rift on account of the association of a few Red Sea shells with Mediterranean ones in the Clypeaster sands near Giza Pyramids which Neumayr recognises as Middle Pliocene. From the work done on the west side of the gulf it has been shown in the above Report that a few Pliocene fossils associated with Miocene have been found in the reefs and beach deposits there.

From observations made on the Sinai side of the Gulf of Suez, it is

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* "Explor. geol. dans la penins. Sinaïtique," 1900, Bull. de l'Institut Egyptien.

† Op. cit.

now possible to add some additional information to that already existing concerning the origin of this arm of the Red Sea. Before doing so, however, it would be well to give a general outline of the history of this sea-arm, as far as can be gathered from observations on both sides of the present gulf. Previous to the Miocene period this area (except for the small piece of land at Wadi Tayiba where there is a little Oligocene) appears to have been a land surface. Only a few patches of Upper Eocene are known on the Sinai side, and except for the place already mentioned, no Oligocene has been discovered. This may be due to the fact that the base of the Miocene is not visible in many cases further to the north, as in every case on the Egyptian side of the Isthmus of Suez, the Oligocene sands and gravels are seen beneath the Miocene beds. At the close of the Oligocene period or during Lower Miocene times, during which denudation seems to have been very active, there was a subsidence of the whole area including the Isthmus of Suez and the district between Cairo and Suez along a line joining Gebel Atâqa and Gebel Tura, as well as the district between the former range and the northern Gallâla, and the area extending from the foot of the present Red Sea hills to the plateau of El Ti and the igneous hills of the Sinai Peninsula as far south as the latitude of Abu Shâr. Into this depression the waters of the Mediterranean came, and the deposition of the Middle Miocene rocks was begun.

That the Gulf of Suez was an arm of the Mediterranean at that time is proved by the fauna of the Miocene having affinities with the fauna of that sea, and none with that of the Indian Ocean. This shows the Gulf of Suez to have been in existence before the Red Sea, as if they had existed simultaneously there would have been an admixture of Mediterranean and Erythræan species.

After the close of the Miocene period, there was a re-elevation of the area under discussion; the sea retreated, except perhaps in the lowest part of the trough; denudation took place; and the Upper Miocene beds (if ever present) were removed, during the continued rise of the land. Subsequently, towards the close of Upper Pliocene times, the strain on the beds caused by the upward movement became so great, that they gave way along a N.W.-S.E. line on either side, along the edge of what is now the igneous and sedimentary ranges of the Red Sea hills and the Sinai Peninsula thus forming the Gulf and Isthmus of Suez. Parallel to these main lines of fracture were the secondary ones which bound the Gulf of Suez as it exists at the present day.

Before these secondary fractures took place the land subsided; the

Red Sea, which had by this time come into existence, invaded the depression and the Beach deposits containing Erythæran genera and species began to be deposited. It is after this that the faults which bound the present gulf began to be marked, this being proved by the presence of raised beaches at different levels along the flanks of the hills on the Sinai side. This fact goes to show that the faults on either side of the Gulf of Suez are not synchronous, but that the eastern ones are the older, the series of beaches on the west side showing a gradual rise for a time after the actual fracture took place on the Sinai side.

At the close of the Pliocene or the beginning of Pleistocene times there must have been, not only a submergence of the sedimentary area, but if the deduction of Dr. Hume and the author be correct, a considerable part of the igneous hills underwent submergence as well. During this period were deposited the Pleistocene beach deposits on the hillsides, the brackish water beds of El Qâ, and the conglomerates, etc., found high up the sides and in the beds of the wadis.

As was stated in the "Report on the Topography and Geology of the Eastern Desert," 1902, p. 213, the fault by which the Red Sea was formed is older than those bounding the present Gulf of Suez. It is probable that before the subsidence of the land admitted the waters of the Red Sea there was a comparatively broad belt of land connecting Sinai with Egypt at the place now occupied by Jubal Straits, having deep water close inshore such as exists to-day at Ras Mohammed. Later on, after the Red Sea had submerged the whole area and Pleistocene beds had been deposited, the two faults which bound the present gulf were formed. It thus follows that although geologically the Gulf of Suez was in existence before the Red Sea, in point of age the fractures bounding the former are younger than those which produced the latter.

Section VIII.—IGNEOUS AND METAMORPHIC ROCKS.

Although no detailed description of these rocks has, as yet, been given by anyone, they have been examined and described in various places by different observers.

Russeger * has mapped them generally as syenite, diorite and porphyry. He was of opinion that the sandstone in Wadi Nasb and in various other places was pierced by these various rocks.

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* Op. cit.

Bauerman * describes the igneous and metamorphic rocks in the area between Wadis Baba, Suwiq, Khamila, Um Agraf, and Sidri. He recognises the fact of the younger age of the sandstones as compared with the granites and gneisses, the former lying unconformably on the latter. He, however, calls attention to a basic dyke in Wadi Suwiq which pierces the sandstone but does not allow this fact to hinder him from arriving at the true state of things. In 1871, there was published in the "Ordnance Survey of the Peninsula of Sinai," Vol. I, an account of the geology of this district by the Rev. F. W. Holland. He states that out of several hundred specimens collected he only found two or three of true granite. The main rock in the peninsula he describes as a syenite. (In this description the old unrestricted definition of "syenite" must have been used, viz., a rock of similar characters to that found at Syene in the First Cataract, Aswan). In the section across the peninsula the author makes the gneiss and other metamorphic rocks rest on the syenite, and does not show any intrusions from the latter into it. He thus apparently favours the view, although he states his inability to substantiate it, that the gneiss is younger than the granite.

Walther † describes in a general way the rocks seen by him in his trip to Ras Mohammed, and also up Wadi Hebrân, and down Wadi el Sheikh and Ferân. He favours the view that the granites and metamorphic rocks are older than the sandstone and shows this to be so at the mouth of Wadi Shellâl. He, however, states that the Nubian sandstone is cut by a basalt intrusion in the coast-range of El Araba. This example was examined by the present writer, but the evidence seemed rather against the intrusion theory, as no indubitable proofs of alteration by contact were visible. The appearance of the rocks was all in favour of the sandstone being laid unconformably against a basalt knoll.

In 1900, M. Raboisson ‡ gave an account of his journey to Mount Sinai and back in which ,after giving a résumé of the work of the various observers on the tectonics of the Jordan Valley, Dead Sea, and Wadi Araba, he attacks M. Lartet's views about the relative age of the Nubian sandstone and the granite and metamorphic rocks. The latter was of opinion that the sandstone was subsequent to the granite, etc., and was not altered by it in any way. The former, however, attacks this view and adduces what he considers indubitable evidence to prove the con-

* Op. cit.
† Op. cit.
‡ Op. cit.

trary. He was, however, unfortunate in his choice of a place from which to prove his point. Gebel Abu Alaqa is, as it is described by the Ordnance Survey, Nubian sandstone resting on granite, but not altered in the least. There is not the smallest evidence of contact metamorphism, but at this particular point it is rather a typical piece of sandstone lying unconformably against the granite. In other places, this author also sees the "auréole métamorphique" where the sandstones show alteration by contact with the igneous rocks. He finally concludes that the porphyries have not penetrated the sandstone in the form of veins, but that the granites have passed into the sandstone and altered them. He says that the porphyries, in some cases, have not cut the sandstones by veins, but that fragments of porphyry of widely different size, angular and rolled, have been intimately mixed with the sandstone on the intrusion of the igneous rocks.

Having given a résumé of the views of the different observers in this district, it is now necessary to describe the different occurrences of the various rocks in detail. They will be taken in order of basicity, beginning with the most acid granites.

The rocks may be divided into the following groups:—

(*I*) *Igneous rocks.*

1. Granites.
2. Syenites and diorites.
3. Dykes and veins.
4. Lava flows.
5. Volcanic necks.

(*II*) *Metamorphic rocks.*

1. Gneisses and schists.
2. Metamorphic limestones, garnetiferous schists and altered sandstone.

In the first group three divisions can be recognised, viz:

a) Coarse red granite poor in mica and ferromagnesian constituents.

b) Porphyritic pink granite containing beautiful crystals of orthoclase.

c) Grey biotite-granite which passes locally into gneisses, furnishing the material from which all the gneisses and schists have been derived.

The second group comprises the rocks forming a few isolated bosses in the large plateau to the north of Wadi el Akhdar and Wadi Ferân, and also in Wadi Meâr and Um Laha.

In the third group are included the felsitic and doleritic dykes and veins which cut the granites and gneisses in various directions; while

in the fourth group come the contemporaneous flows seen near Maghara, Serabît el Khâdim, Debbet el Ramli, and at Wadi Tayiba, and the altered acid series on the side of Wadi Khashaba. In the fifth group come the doleritic plugs of Gebels Sawasia, Madsûs, Um Iswad, Mareia, and Samr el Tinia or Qasr Abbas Pasha, and the injected fissures connecting them. The first group of the second class includes the strip of altered rocks stretching from Gebel Madsûs to Wadi Um Agraf; while the second group contains isolated patches of rocks situated in Gebel Matakh el Barûd near the head of Wadi Hebran and in Gebel Um Isnân in Wadi Solâf.

The extent of the Igneous and Metamorphic Rocks.

The igneous and metamorphic rocks may be said to extend roughly from lat. 27°45′ N. to 29° 9′ N. This does not include the small flow in Wadi Tayiba, or the dykes which cut the sedimentary rocks to the north of this boundary. On the western side of the peninsula they may be said, with the exception of the chain of El Araba, to be bounded by the great north-west–south-east fault which separates them from the sedimentaries, and further south by the plain of El Qâ; on the south by the Red Sea; and on the north and north-east by the Carboniferous sandstone and the Debbet el Ramli.

In describing these rocks in detail the order of the above list will be followed.

I. Igneous rocks.

Gebel Um Malaqa.

1*a*. *Coarse red granite.*—Beginning with the most southerly extension of the peninsula, the red granite is first met with in Gebel Um Malaqa. It is to be noted that the granite here differs considerably in character from that found further north, as well as in the Eastern Desert on the western shore of the Gulf of Suez, and approaches more closely to that occurring in the First Cataract at Aswan. The main points of divergence from the common type in this region, are the greater proportion of porphyritic felspars in comparison to the quartz, the presence of a larger quantity of biotite and hornblende, and the marked difference in the style of weathering; for whereas, in the typical coarse red granite of this area, the tendency is to weather into sharp jagged peaks and ridges towering up above its congeners, the type here present tends to the production of rounded hills and domes, approaching in this characteristic the porphyritic pink granite which is found further to the north, and resembling the Aswan granite very closely in its behaviour. There is no doubt, however, that this rock is only an extreme type of the normal coarse red granite, and is younger

than the pink porphyritic variety which it resembles so closely in some of its characters. To the south of Wadi Um Malaqa, this rock is found intruded in the complex of andesitic dolerite, diorite-quartz-felsite, and fine-grained granite which forms Gebel Ât el Gharbi. On the sides of this wadi coarse hornblende-granite is found cutting the grey granite in the foothills, the whole being dyked by dolerite, while in Gebel Um Malaqa itself red granite assumes complete sway. Out in the coast-plain several isolated knolls of this granite (also called Gebel Um Malaqa) rise up through the sand and boulders of the recent deposits like islands in a sea.

Gebel Sakhara, Abu Markh, etc. Further to the north in the main range Gebel Sakhara, and Gebel Abu Markh near their summits are composed of the same rock; while to the east in the foothills, Gebel Motalla and Gebel Um Gatîh, and the two isolated masses in the plain, Gebel Hemcrat, and Gebel Masraia, are likewise of red granite, the latter hill being cut by broad dykes of dolerite and quartz-felsite having a general bearing south-west-north-east. The latter rock also contains basic patches (segregation-patches).

Gebel Rashid Khanasir, etc. To the north of Abu Markh the main hill-mass consists of the same type of rock streaked with dykes and veins of dolerite and quartz-felsite, the lower foothills which bear the name of Gebel Mokateb not differing in any way from it. In Gebel Rashid are many dykes of dolerite and quartz-felsite, the former weathering into a soft greenish mass. At the point where Wadi Rashid opens towards the plain are two isolated masses bearing the name of Gebel Khanasir, also composed of red granite and much dyked by dolerite and quartz-felsite.

Gebel Tihî, Marît, and Um Hash. To the north of Gebel Rashid comes the hill-mass composed of the peaks of Gebel Tihî, Marît, and Um Hash, all consisting of the same type of red granite, streaked with intercrossing dykes and veins of dolerite and quartz-felsite having the same general direction as previously. On the top of one of the peaks of Gebel Tihî a small wedge of sandstone was found enclosed in the granite, altered almost to a quartzite. This must be a last remnant of a very ancient sedimentary series which at one time covered these rocks, and which must be older than the Carboniferous, as the latter rocks are found resting unaltered on the eroded surface of the granite further north.

Sandstone in Granite.

The outlying hills in the plain consist of the same rock, and are much cut by dykes of fine-grained dolerite, and coarse quartz-felsite with porphyritic felspars; the dykes of the latter rock are often about 3 metres wide and sometimes form compound dykes with the former, their bearing being the same as that of those already described.

DYKE HILL OF GARN ATUD IN COAST PLAIN.

Gebel Um Sidri, Um Rieh, Teman, and Temalli.

Beyond Wadi Um Hash there extends a mass of hills forming the watershed, of which the principal peaks are Gebels Um Sidri, Temân, and Temalli; while a subsidiary range to the east of Um Sidri is formed by Gebel Um Rieh. There seems to be a fault between this hill and the main range, as the drainage instead of flowing west to the plain collects from both sides in a longitudinal valley lying north and south and finds it way out to the north and south. While in Gebel Um Rieh the two classes of dykes are fairly numerous, further to the north in Gebel Temalli they are much fewer in number and appear to be dying out, only a few stragglers of quartz-felsite being seen.

Recent sandstone on hills.

On the summit of the foothills of Gebel Temalli a small patch of Pleistocene sandstone was met with 424 metres above the sea.

Gran Atûd.

Lying out in the plain about 3 kilometres from the main mass of the hills is a remarkable double-peaked knoll with precipitous sides called Gran Atûd, which consists of coarse red granite.

Gebel Um Shomer, Gebel Shiddiq.

Beyond Wadi Isla at the south side of Wadi Emlaha the red granite ceases to occupy the whole of the hills; it sweeps away in a north-easterly direction towards Gebel Emlaha and Um Shomer where it forms all the higher peaks, again bending back in a north-westerly direction towards Wadi Shiddiq, the lower hills being composed of grey granite or quartz-diorite, into which the former rock is intruded. The boundary of the red granite to the north is the base of the ridge composed of Gebel Wigrân and Giddet el Êla, where it comes up through the grey variety; it then sweeps across the plateau of Fersh Abu Loz, and runs along the eastern side of the dolerite ridge of Koli and Um Iswad to the watershed range of which Um Shomer and Abu Shêqer form prominent peaks. This area is veined and dyked by quartz-felsite and dolerite in some places (as in Gebel Giddet el Êla) so much so that the dykes form half the rock and are such a prominent feature that this hill has derived its name from them.

Wadi Ilti. Gebel Sawasia.

In Wadi Ilti red granite is found cutting the grey biotite granite which here forms the country rock; while in Gebel Sawasia (Ilti of Ordnance Survey) it also occurs, being in turn cut by the doleritic neck which forms the summit of this hill.

In Wadi Meâr opposite Gebel Madsûs this granite again appears intruded in the grey granite, and also in Wadi Khrêta which is the continuation of Meâr.

Gebel Um Sâ, Gharba, Watia El Elwi, and Sinai massif.

The large plateau-like mass of Gebel Um Sâ, extending to Gebel Gharba, as well as Gebel Watia, El Elwi, and the mountains composing the Sinai massif are all composed of the true red granite as it is known from the Eastern Desert. In this massif occurs the doleritic neck and

injected fissure of Gebel Samr el Tinia or Qasr Abbas Pasha, so named from the ruins of a summer palace built by this khedive on its summit.

Gebel Serbâl.

The next place where red granite is found occupying a commanding position, is in the range of Serbâl where it forms the jagged ridges and peaks so characteristic of this mountain. Gebel Bêdhat Um Takha, the most southerly point, and Gebel Um Lahm, the most northerly of the range, are also composed of this granite. This mountain seems to have risen on the boundary-line between the pink porphyritic variety and the grey, the latter apparently being sheared and converted into gneiss, while the former was left unaltered. An important point about this range is, that its axis lies roughly parallel with the north-west-south-east line of the valleys which belong undoubtedly to the class of "Rift Valley." The next mass of red granite in point of latitude is an irregular patch measuring 17·5 by 16 kilometres. It begins near the mouth of the Wadi el Akhdar, forming here a steep-sided plateau called Gebel

Gebel Yenna.

Yenna which abuts on Gebel Goze and El Banât, these latter completing its west and north-west sides. In this rock occur large intrusions of a syenite-felsite; while cutting both are a number of thin dykes and veins of a glassy and spherulitic felsite or felsophyre. This plateau is

Gebel Retema, and Hamra.

continued on into Gebel Retema and Hamra, forming the high red mass which borders Wadi Barra on either side, and then stretches away towards the head of Wadi Shêqer, where it gives place to the grey granite and metamorphic rocks which form the country to the north. Round the mouth of Wadi Barra this granite cuts through the pink and grey varieties and stands out in a striking manner from them. To

Wadi Barra and Lebwa.

the north of the water-parting between Wadi Barra and Wadi Lebwa, this rock forms a wide plain which is drained by the latter wadi; it forms a small ridge which separates the basin of Wadi Rahaba from Lebwa, but is eventually breached by the latter where it discharges its water into Wadi Aqr. On the other side of this ridge the grey granite forms the open country drained by Wadi Rahaba. At the mouth of Wadi Lebwa the red granite is replaced by the metamorphic series into which it sends intrusions.

Dykes.

Near the head of Wadi Aqr the granite is cut by dolerite or diabase dykes 6 to 9 metres wide running is a south-west–north-east direction, while some quartz-felsites also cut it, having the same orientation. In Wadi Lebwa and Barra on the other hand, the dykes seem to cross each other at right angles, the quartz-felsites running in a south-east–north-west direction.

Wadi Nisrin and Rumâna.

At the corner of the plateau of grey granite which occupies the country to the north of Wadi Rumâna there appears a mass of fine-

grained red granite lying between this wadi and that of Nisrin. It forms an irregular patch measuring 6·5 by 4·5 kilometres at its greatest length and breadth. This rock is intrusive in the grey granite which forms the main plateau extending from Wadi Rumâna up to Wadi Siq. On the top of this mass was found a small patch of spherulitic felsite of which the relations to the underlying rock could not be determined; it is, however, very probable, that it is the remains of a small sheet or vein of the same magma from which the dykes and veins met with in the granite of Gebel Yenna were injected. Cutting both the granites, is a dyke of porphyritic dolerite 4 metres wide, in which occur felspars measuring 8 by 2·5 millimetres, while they are also seen to form "glomero-porphyritic" patches; calcite is also present in places. Some small dykes weather out very readily, forming narrow gullies down which the water makes its way, often ending in a precipitous face over which it is impossible to descend. The tendency of this red granite is to form sharp ridges; and in the watercourses steep and polished waterfalls, over which it is dangerous to travel, while lower down, the valleys are filled with huge boulders, mixed with a fair amount of disintegrated rock, which in spring supports a luxuriant crop of "hamada" a succulent plant much relished by camels.

The only other place where the red granite appears is in Gebel Abu Darba, a high conical hill in the granite range of El Araba extending down the coast of the Gulf of Suez, from the mouth of the Wadi Ferân to Gebel Abu Suwêra. It occurs all through the range intruded into the pink variety and the granophyre which form the main mass of the range, the whole being dyked and veined in a marvellous manner by dolerite which seems to follow lines of flexure. El Araba range.

1*b*. *Pink porphyritic granite.*—This rock is characterised, as its name implies, by its pink colour, its possessing large pink orthoclase felspars which give a striking appearance to it, and by a much smaller proportion of quartz than that which the previous type of granite contains. Its mode of weathering is also quite different; for whereas, in the red granite the tendency is to form sharp, jagged peaks, and narrow ridges, this rock tends rather to the formation of flat, rounded domes, and low rolling bluffs, which, when seen from above, suggest the "roches moutonnées" of the French geologists. It differs also from the previous rock in its tendency to scale off in thin sheets parallel to the surface, which crumble under foot and make very unsafe walking, especially in descending a hill of this rock. In every case also, it forms the lower hills, never dominating those formed by the red variety, and so constant

are the characters above enumerated, that it is possible to determine this rock with certainty several kilometres off.

This rock, where it occurs in quantity and in a fresh condition, would make a beautiful statuary stone as it is remarkably free from blemishes.

Coast range. Gebel Ghub. The southernmost point at which the true porphyritic granite occurs is in Gebel Ghub in the coast range extending from Ras Gehân on the north, to the mouth of Wadi el Araba, near which the above hill is situated. In this range, as previously stated in the description of the red granite, there is a complex of different rocks, the most important of which are the pink granite and granophyre or fine-grained granite; into the latter the former sends veins and apophyses, the whole being likewise cut by red granite and dolerite intrusions. The main mass of the range may be said to be composed of pink granite and granophyre, and the various peaks, viz., Gebel Batn, Abu Hoshwa, Abu Gatâr, with the exception of Abu Darba, are likewise composed of this rock.

Wadi Meâr. In Wadi Meâr near the mouth of Wadi Khrêta, pink porphyritic granite is seen intruded into the grey granite which here forms the country rock.

Wadi Hebrân. Further north in Wadi Hebrân this rock occupies a tract of country roughly 6·5 by 2·5 kilometres in size, stretching from Gebel Wagîra and Hebrân on the north, to Gebel Weber on the south, and from Wadi Emlaha on the west to the foot of Gebel Matakh el Barûd, a range of gneiss and metamorphic rocks which has been metamorphosed by contact with the granite. In this area the typical rounded summits and dome-like hills are seen with no outstanding points to help one to distinguish one from another.

Gebel Hebrân. In Gebel Hebrân the pink granite is veined by the coarse red variety; while a dyke of quartz-felsite about 3 metres wide, running east and west, and extending from Gebel Wirga on the west, a distance of 5 kilometres, cuts this hill and continues for several kilometres further. Numerous veins and dykes of dolerite are also met with in this hill, and seem to radiate from Gebel Moreia or Tarbush.

Gebel Wirga, Ramuz, and Geba. Another patch of this rock forms the foothills to the range of Gebel Serbâl, occupying an area of 13 by 6 kilometres or so. This area extends from Wirga on the south to Wadi Geba on the north, and from Gebel Serbâl on the east to El Qâ on the west, including in it Gebel Sigillia, Wirga, Ramûz and Geba. Compound dykes of quartz-felsite and dolerite cut these hills in an east-and-west direction, while simple dykes of the former rock also occur like that mentioned previously as extending

GRANITE VEINING DIORITE, WADI MEAR.

from Wirga to Gebel Hebrân. The granite in this area is typical in its style of weathering, some splendid examples of domes being met with on the summit of Wirga and the Fersh el Ramûz.

Its relations to the neighbouring rocks are very distinct; it is cut and veined by the coarse red granite, while in turn, it intrudes into the gray micaceous variety, which lies on it to the south.

This rock is not met with again until the middle of Wadi Solâf is reached; after passing the gneiss and schist which form the sides near the mouth of this wadi and the metamorphic patch at Gebel Um Esnân it once more occupies the field. In this hill there is a complex of rocks formed by contact metamorphism, this granite being the agent which produced the metamorphosis, by sending apophyses into the shales and limestones which compose it. Veins also are met with in the gneiss and schist which also undoubtedly belong to the same rock. Beyond the area of metamorphic rocks which lies round the Naqb Engawe and the mouth of Wadi Solâf, the pink granite is seen to occupy the whole of the country from the foot of Gebel Moreia or Tarbush up to the Naqb Hawa, Gebel Gharbi and Watia on to and beyond Wadi el Sheikh, a distance of 23 kilometres, while the breadth is 10 kilometres. The eastern boundary has not been seen, but on the north it is seen to be bounded by a mixture of pink and gray granites at the head of Wadi Magheirat, the line being parallel with Wadi el Sheikh until within a kilometre of Wadi Solâf when it crosses the water parting between Wadi el Akhdar and El Sheikh and connects with the next area to be described to the north. About 2 kilometres west of Wadi Solâf it crosses Wadi el Sheikh and sweeps round toward Gebel Um Esnân.

Gebel Um Esnân.

Between these two wadis the pink granite forms the main rock, being cut by two sets of doleritic dykes one of which runs S.W.-N.E., while the other is at right angles to the first, being the older and more basic and weathering spheroidally, often forming a trench and attaining the width of 6 metres. They also form compound dykes with the red granite. This causes the pink granite to be thrown into ridges where the harder set of dykes predominates; while in the places where the two sets are in equal quantity it forms rounded hills. Behind Gebel Watia it also appears and is cut by dykes of granophyre, while further up Wadi el Sheikh it is replaced by red granite.

Country between Wadi Solâf and Wadi el Sheikh.

The next patch to be described is that which lies on either side of Wadi el Akhdar, and is connected to the last-mentioned piece by a narrow band. In length it is 12·5 kilometres by 7·5 at its greatest width. It begins about a kilometre to the south-west of the mouth of Wadi Barra. On the north of Wadi el Akhdar the boundary runs

up Wadi Retema until near its head, where the large boss of red granite crops out. Beyond this boss the boundary line to the north-east is practically on the line of Wadi Esh, from thence running in a north-easterly direction by the head of Wadi Bum to Naqb Shêqer, then bending south once more towards El Akhdar, which it touches about 2 kilometres from En el Akhdar, from which point it runs more or less parallel to this wadi, until it connects with the mass previously described. On the north-east it meets the gray granite, while on its southern side it has a mixture of the pink and grey varieties. Through it run dykes of quartz-felsite (S.W—N.E), and dolerite N. of E. and S. of W.

Between Wadi Shellâl and Sidri.

The next place where this rock occurs in mass is between Wadi Shellâl and Sidri, where it forms a high ridge of hills 10 kilometres long by 5 at its greatest extension. It bears a few isolated outliers of Carboniferous beds, and further to the north eventually disappears under this formation altogether. From this patch a narrow strip runs along the side of the fault line across Wadi Shellâl, where it forms a small boss bounding the valley. This is undoubtedly the same as that which forms the east side of Wadi Baba, the connection being hidden by a thin covering of Carboniferous beds. In this district it is intrusive in the gneiss, which forms a good part of the country round this place.

Opposite the mouth of Wadi Budra, on the side of Wadi Sidri, a small knob of this rock is exposed from under the Carboniferous sandstone, being evidently part of the main mass faulted down.

Gebel Ât el Gharbi.

(Ic) *Grey granite.*—Beginning at the most southerly occurrence of this rock, the first to be described is that of Gebel Ât el Gharbi, where there is a complex of andesitic dolerite, fine-grained granite, diorite, red granite and this rock. Round the base of this hill, the foot-hills are composed of grey granite.

Wadi Um Malaqa.

Going northwards the next patch met with is at Wadi Um Malaqa, where there is a mixture of a coarse, red granite and a prophyritic grey variety. From this point to Wadi Emlaha none of this rock is met with, but at the latter place grey granite passing into diorite, or quartz-diorite is met with. There, up to and beyond Wadi Shiddiq, it forms a triangular patch in the foot-hills, its apex pointing northwards. Its greatest length is 12·5 kilometres, and its breadth is 10 kilometres. Along the edge of the main hill-mass is a fringe of dioritic rock much cut up by a grey granite. On reaching Wadi Meâr it is found that grey granite has usurped the ground entirely, as it appears on both

sides; it extends southwards almost to the crest of Gebel Wigrân; eastwards as far as Wadi Khrêta; northwards about a third of the way between Wadis Meâr and Hebrân; until about one third of its length from its mouth it crosses over to Wadi Hebrân, running in a northerly direction until it meets the pink granite of Gebel Wirga. This mass is cut by a few veins and dykes mainly of dolerite; but in Wadi Ilti red granite cuts it; while there are also compound dykes of an augite-diorite and a micro-granite, and higher up quartz-felsite dykes become abundant some of them 6 to 9 metres wide.

Fluidal felsites are also found in this wadi; while in places also the granite becomes very micaceous.

In Wadi Hebrân near its mouth, grey granite cuts a dioritic rock and is itself veined by a white binary granite. In the granite in this wadi very micaceous patches occur, and dykes of dolerite (S.W.-N.E.) likewise cut it.

The next place where this rock is met with is in Wadi el Sheikh, about half-way between Wadi Magheirat and its mouth. It extends to within one kilometre from the mouth of the wadi, then becomes gneissose, and in about 600 metres from this point passes into a true gneiss. This patch is somewhat irregular in outline, and sends a long, narrow tongue up the side of Wadi Solâf, between the gneiss and the pink granite. In its greatest length and breadth it is 15 by 7·5 kilometres. On the north it is bounded for a while by the drainage line of El Akhdar, the junction-line between this rock and the red granite having evidently determined the course of the wadi; but further up the water has evidently departed from this line, as the grey granite sends a tongue in between the red and pink varieties, the boundary lines in this case being likewise marked by the tributary wadis of Satakh and Retema. On the east and south it is bounded by a large area of the pink variety. In this area the rock is much dyked by dolerite and red felsites. Wadi El Sheikh.

The next grey granite area occurs between Gebel Yenna and Banât on the south, over the wadis of Rumâna and Rahaba up to wadis Sidri and Siq, on the north, and east as far as that of Barq. It runs up wadi Siq for about 10 kilometres, and is seen wherever the small branch wadis have cut through the Carboniferous sandstone, so that it undoubtedly forms a continuous sheet underneath the latter rock. It is bounded on the south and west and north by the gneiss hills which lie on the north side of Wadi Ferân, and also form the hill-mass between this valley and that of Sidri and Um Agraf, and on the east by the complex of pink and grey granite and the red variety near the

head of Wadi Lebwa. The gneiss above-mentioned has undoubtedly been derived from the grey granite. The patch under consideration has a maximum length and breadth of 20 by 19.5 kilometres, being widest on its southern side. This rock forms a large, high plateau without any prominent points, except where there are intrusions of other rocks, e.g., the red granite patch overlooking Wadi Nisrîn, and the syenite intrusion near Wadi Aqr. Its surface is divided into flat-topped patches or fershes, e.g. Fersh Nisrîn, Fersh Sidri, and Fersh Abu Aleqa, each being named from the wadi which drains it. In its southern part it is very much dyked mainly by dolerite, as much as one fifth of the entire rock being composed of this rock. The latter weathers very easily and in a spheroidal manner, in most cases being rather lower than the surrounding rock. A prominent, red dyke of quartz-felsite, from 3 to 4 metres wide, makes its appearance near the intrusion of red granite overlooking the Nisrîn valley, and is continued into the plateau where it could be traced a distance of 6.5 kilometres.

From the beginning of Wadi Siq to the mouth of Wadi Barq, there is a boss of quartz-felsite intruded into this rock which forms steep scarps on the sides of both these wadis.

Wadi Um Shêqer, etc.

The only other place where this rock occurs is in the neighbourhood of Wadi Um Shêqer, Entish, etc., where it is capped by isolated outliers of Carboniferous sandstone. On the west it adjoins an area of metamorphic rocks ; on the north and east it disappears under the Carboniferous sandstone ; while on the south it is cut off by the pink and red granites. This patch has a maximum length and breadth of 12·5 by 7.5 kilometres. It is much cut by dykes of fine granite and quartz-felsite.

With regard to the relations between the metamorphic complex and this rock, no definite evidence could be found, but the presumption is that the fundamental rock of the former is the older.

This grey granite, on account of this being fairly rich in mica, lends itself to easy weathering, and also tends to form flat-topped hills or plateaux, instead of rugged ridges. Its tendency to become gneissose is also fostered by its wealth of mica, and there is little doubt that all the gneiss on the western side of the peninsula at least has been formed from this rock.

Mixture of pink and grey granite.—Under this title has been mapped certain areas composed of such an equal mixture of these two kinds of granite that it was impossible to separate them except by spending months surveying them on a large scale, a work which would not

justify the extra expenditure. These areas form a crescent-shaped mass, the points of which lie at the head of Wadi Sheqer and the mouth of Wadi Harqûs respectively, while the middle is at En el Akhdar. The grey granite is gneissose, as is sometimes also the pink variety, while the mass is much cut by dykes of quartz-felsite and dolerite. Its southern boundary does not reach Wadi el Sheikh, while its eastern boundary was not reached as the party had to turn westward in order to finish the remainder of the country.

2. *Syenites and diorites.*—Of the former there are only two known occurrences, viz., a small boss 1·5 by one kilometre in the grey granite plateau on the north of Wadi Aqr, and in the mass which forms the north side of the plateau of Gebel Yenna and Banât. The latter is intruded into red granite, and on the south side is another small tongue of the same rock, between the two being numerous small dykes, which are good examples of fluidal intrusions. The rock is dark-red with porphyritic felspars in a felsitic ground-mass. The patch is roughly triangular in outline, and measures 10 by 7·5 kilometres at its widest part. It seems a fairly hard, resistant rock, and the formation of the plateau is no doubt due to its combination with the red granite, the softer grey granite and micaceous gneiss having weathered more easily leaving the harder rocks standing high above their neighbours.

Diorites are first met with in Wadi Emlaha which drains the Um Shomer range on the west. Here it passes insensibly into quartz-diorite. At the mouth of Wadi Meâr it occurs on either side, and is a very fine rock rich in hornblende, and much cut by a grey biotite-granite. Further up it occurs in a patch near the foot of Gebel Madsûs, but here it is a more micaceous variety. It is much cut by wide dykes and veins of quartz-felsite.

3. *Dykes and veins.*—Although the igneous area is more or less dyked and veined all over, still in certain places they are more crowded together than in others, while the rocks call for special mention on account of some characteristic which they possess. Starting from the south, the first to be noted are the dykes in the outlying hills to the west of Gebel Tihi. These are much cut by doleritic dykes running N.E–S.W., while there is also a porphyritic quartz-felsite dyke about 3 metres wide, which shews fine secondary growth of the felspars. Further north, to the west of Wadi Temân, the outlying hills are also much cut by dolerite and quartz-felsite, while the main range is also streaked by these, the dolerite being the younger. In the foothills of Um Shomer there are east and west dykes of quartz-felsite.

Wadi Alti. In Wadi Ilti augite-dolerite forms compound dykes with a micro-granite having a bearing S.W.–N.E; quartz-felsites are also very abundant higher up, ranging from 6 to 9 metres in width ; while others are narrower and more glassy, exhibiting good fluidal and spherulitic structures. In addition to these some dolerite and diorite dykes were also seen. Gebel Sawasia at the head of this wadi is much cut up by fine grained quartz-felsite while Gebel Giddet el Ela, Wigrân, etc., are literally cut to ribbons by dykes, the former deriving its name from this (see Topography p. 81). In Gebel Ramûz and Geba compound dykes of quartz-felsite and dolerite are found running in an east and west direction.

Gebel Sawasia.

The coast-range is much dyked and veined by a fine-grained dolerite.

Wadi Hebrân. In Gebel Hebrân, a quartz-felsite dyke 3 metres wide and running S.E.–N.W., is seen to be continuous from Gebel Wirga, a distance of 7·5 kilometres. A few dolerite dykes also occur which seem to radiate from Gebel Mareia. At the head of this wadi, quartz-felsite and a syenite-felsite cut the gneiss in that region.

Country between Wadi Gharbi and El Sheikh. In the area between Wadis Gharbi and El Sheikh two sets of dolerite dykes are met with, one running S.W.–N.E., the other and older runs at right angles to the first, and reaches a width of 6.5 metres, weathering spheroidally, and forming trenches in the granite, while the former stands slightly out. The younger dykes have been traced into the doleritic neck of Gebel Mareia, and are seen to radiate from this mass or its probable extension underground. The older set forms a compound dyke with the red granite. Round about Wadi el Sheikh outside El Watia, dolerite dykes, ultrabasic rocks in sheets and veins, and a syenite-felsite dyke running N.W.–S.E. cut the granite. On either side of this wadi the two sets of dolerite dykes persist, the orientation of the younger changing until it becomes almost north and south. When examined in the field this rock splits into thin splinters under the hammer, and seems to contain felspars resembling orthoclase, but this must be settled by the examination of thin slices under the microscope.

Wadi Ferân. Near the head of Wadi Ferân the dykes in the gneiss are mainly quartz-felsite, although a few are doleritic too. Numerous veins of pegmatite also occur in the gneiss. Below the mouth of Wadi el Akhdar the gneiss is simply riddled with dykes and veins, the former being mainly quartz-felsite, some of which attain a width of 6·5 metres. These belong to two periods, the elder running S.W.–N.E., while the others bears N. and S. Interlacing these are numerous veins of dolerite mainly lying in a N. and S. direction. This mixture of rocks pro-

duces a multi-coloured mass, which when seen with the setting sun on it is simply wonderful, the bright red of the felsite, the dark-brown of the dolerite, and the sombre hues of the gneiss combining to produce a very striking effect. This state of things persists for about half a kilometre and then returns to the normal state. Below the Oasis of Ferân, dykes of several kinds occur in the gneiss, of which two are quartz-felsite (one of them gneissose), while fine-grained red granite and the pink, porphyritic variety occur as veins and intrusions. Further down there is a great increase of dykes once more, these being mainly of the doleritic type much weathered and lying in a north and south direction.

Wadi Rummana and Rahaba.

Returning up Wadi Rummâna, in the plateau overlooking Wadi Nizrîn, a remarkable dyke 4 metres wide is met with in the red granite. It is doleritic and contains some very large felspars measuring 7·5 by 2·5 centim., some of which also form glomeroporphyritic patches. In Wadi Rahaba (the continuation of Wadi Rummâna) there occur dykes and veins of dolerite and quartz-felsite, while in the latter wadi the doleritic intrusions are so numerous as to form about 1/5 of the entire rock.

Wadi Aqr.

In Wadi Aqr, in the metamorphic complex in which it heads, there are numerous thin dykes of quartz-felsite, but the diabases form wide intrusions.

Wadi el Akhdar.

Near the mouth of this wadi, the high plateau of Gebel Yenna contains some fine examples of veins of fluidal rocks. Higher up the valley to the east of Wadi Bârra, the granite is much cut by S.W.—N.E. dykes of dolerite, some of them 6 metres wide. Further on beyond the mouth of Harqus, a dyke of porphyritic quartz-felsite S.W.—N.E., and one of dolerite N. of E. and S. of W. were met with ; while at En el Akhdar a boss-like mass of coarse, porphyritic quartz-felsite is seen, as well as several other smaller dykes of this and a doleritic rock.

In Wadi Sheqer there are many dykes of fine granite and quartz-felsite in the metamorphic area. In the neighbouring Wadi Barq occur veins and dykes of a felsitic rock, together with S.W.—N.E. dykes of dolerite much decomposed. These occur in the metamorphic complex previously mentioned.

Near the junction of the above-mentioned wadi with that of Siq, there occurs a boss of quartz-felsite in the gneiss ; while further up the latter valley a dyke of gneissosse quartz-felsite is met with ; and in the continuation of this waterway (Wadi Um Agraf and Sidri), dolerite and felsite dykes, having a north and south bearing, abound.

Dykes in sedimentary rocks.

Leaving the igneous and metamorphic areas, the dykes and veins in the sedimentary district only remain to be noticed, the first being those of Gebel Hadud. This hill is an isolated knoll of Cretaceous limestone lying on the north-east corner of the plain of El Markhâ. In it occur some black veins of a tachylitic basalt about 30 centimetres thick.

Not far away from this hill, a dyke of dolerite, running north and south, is seen to cut the Carboniferous limestone in Wadi Shellâl, but as it was not met with on the surface of the plateau, it may be concluded that it is not one of the later dykes.

On the edge of Wadi Baba, near its junction with that of Suwiq, a much-decomposed dolerite dyke cuts the Carboniferous sandstone, but is soon masked by blown sand, its bearing being south-east–north-west. This is the intrusion from which M. Raboisson* formed his opinion that the igneous rocks were later than the sandstone and had been intruded into them.

Wadi Nokhel.

In this wadi where it enters the sea, a dyke of dolerite 5 to 6 metres wide cuts through the limestone and enters the sea a little to the south. Its bearing is practically north and south, and it was again met with in Wadi Hamr apparently continuing for some distance to the north. Where it joins the limestone its edges are tachylitic, and hydrocarbons have been developed in the rock which gives off a strong smell when struck by the hammer. This is true of every place where the junctions have been examined. In two other places in Wadi Hamr small veins were seen in cracks.

Gebel Hammâm Farûn.

The next place where a dyke was seen was in Gebel Hammâm Farûn, where a N.E.—S.W. doleritic intrusion pierced it on the southern side. It was not noticed on the north side, however, and may be only local, as in the next case which occurs on the divide between Wadi Abu Qâda and Bagha. Here, what appeared at first to be black limestone was found, but on examination proved to be a dolerite dyke with a fringe of dark limestone on either side. This intrusion was not seen to extend any distance. The reason for this perhaps is that as the dyke occurs in the Cretaceous marls, and they are exposed only for a short distance, it may not have penetrated the higher beds. In fact, it did not seem to reach the upper beds of these marls.

4. *Lava flows.*—These are found in two districts only, viz., that extending from Maghara up Wadi Baba and on to the Debbet el Ramli, and in Wadi Tayiba. Taking the first one, the first patch of volcanic

* Op. cit.

rocks found was on the hill-top overlooking the turquoise mines in Gebel Maghara. Here it was a coarse basalt about 27 metres thick, and evidently a subaqueous flow, as no signs of steam-holes or scoriæ were met with to suggest a subaerial origin. This patch must have been continuous with the other three which are seen in the neighbourhood, part of it having been carried down by a trough-fault which lets the Cretaceous sandstone into the plateau. This first patch is about 2 by 5 kilometres in length and breadth. To the north of Wadi Qena the largest patch of this rock is found; on the east it is bounded by the main line of fault, which has let down the whole of the country to the west. In character it is like the others, and in shape, a long, narrow triangle measuring 5 by one kilometres. Close to it is another small patch separated only by a small drainage way. The next large patch occurs just behind the high granite ridge which overlooks Wadi Shellâl. It is an irregular piece which has been let down by a V-shaped fault into the sandstone.

On the top of Serabît el Khâdim and the hill immediately to the north-east of it are found caps of this rock. It is to this that the peculiarly rounded appearance of these hills is due. The last occurrence of this rock is met with on the top of Gebel Hameier on the edge of the plain of Debbet el Ramli. It forms a steep scarp to the south, gradually thinning out and disappearing under the blown sand of the above-mentioned plain. The thinning is due entirely, as far as could be seen, to the erosive power of the sand-blast which is here very powerful. Its thickness here is about 39 metres, and its total area is 5 by 2·5 kilometres. Underneath these patches a certain amount of alteration of the underlying rock has taken place, the sandstones being converted into quartzites. Other hills have been met with having this alteration-layer, and this has been regarded as a proof of the former greater extension of the basalt.

Age of this lava.—It is difficult to assign a definite age to this rock, as there are not sufficient data from which to arrive at a certain conclusion. After some search among the underlying sandstones two specimens of *Lepidodendron* were found, this shewing that they were in all probability of Carboniferous age, but no result was obtained from the beds, which are higher than the basalt. It has therefore been regarded as late Carboniferous in age. This rock is so constant in its position, that it has been used successfully as an indicator of the upper boundary of the Carboniferous sandstone, the lines closing up perfectly although it was used over a fairly large area. That it is not

an intrusive sheet is fairly certain, as in the many exposures it is to be expected that some definite evidence of its eruptive nature would have been found. Moreover, an intrusive sheet, as a rule, has a definite outcrop along a certain line, and does not occur in isolated patches, forming a sort of crescent with its concavity to the south-east. The source from which these rocks have been derived is a more doubtful matter. The next class of rocks to be described, viz., volcanic necks, shews such a suggestive relationship to these flows when the two are plotted on a sheet, that the conviction is borne in upon one that these necks are the remains of the vents from which these basalts have been poured.

Wadi Tayiba.

The next place where lavas are met with is in Wadi Tayiba, especially on the south side of it. The first patch occurs at the mouth as an interbedded lava in what has been described as a Beach Deposit (Miocene). It is a much decomposed basic rock, is tilted at a steep angle, and is only about 12 metres thick. It has probably been torn away from the other interbedded lava by a fault which has thrown the latter down against the Cretaceous rocks. As to the source of these rocks, it is impossible to say whence they came, unless the dyke previously described from this area is the remains of a fissure from which they were poured. The fact that they thin out towards the east is against this, so that the most probable place to look for their source is under the waters of the Gulf of Suez.

5. *Volcanic necks*.—These rocks, as already stated above, form a sort of horse-shoe with the convex side turned to the north-west. They occur in the hills of Gebel Koli, Abu Mezraq, Sawasia, Madsûs, Mareia and Samr el Tinia.

The ridge of Koli and Abu Mezraq is a large mass, over 7 by 3 kilometres in length and breadth, rising with sheer sides through the granite which forms the country. Apparently connected with it by a narrow injected fissure is Gebel Sawasia, another mass 2·5 by one kilometre, which rises up the centre of the hill, exhibiting all the characters of a volcanic neck, and on one side forming a sheer cliff where the granite has been removed. Four or five kilometres to the north of the last occurs the hill of Madsûs, the centre of which is formed of a mass of coarse dolerite similar to that which forms the other masses previously mentioned. Further to the north-east occurs the hill of Gebel Mareia, which is composed of a mass of dolerite over 5 by 3 kilometres in length and breadth, while eastward is the mass of Samr el Tinia, which is made up of the same rock. All these masses are coarse

dolerite which veins the granite in which it occurs and often sends dykes out into the surrounding country. If, as has been stated in the part on the lavas, these are the remains of the vents out of which the lavas were poured then their age is late Carboniferous, and the dolerite dykes which occur in the gneiss and other rocks on which the Carboniferous rocks are laid, are older and belong to another period to that of these necks. It has been stated previously that there were two sets of dolerite dykes one of which was connected with the large masses of dolerite and was the younger; it is therefore likely that the older series is not in any way connected with these necks.

(II) Metamorphic rocks.

1. *Gneisses and schists.*—These rocks occur in the district lying between lat. 28° 36′ and 29° N, and long. 33° 30′ and 33° 50′ E. They can be roughly divided into two groups, viz., true gneisses and schists, and a complex of metamorphic rocks. Taking the last named group first, it occurs in one large patch extending from the neighbourhood of Wadi Barq eastward as far as the Wadi Siq. This is composed of two fundamental rocks associated with several others of minor importance, these being:—

1. Much altered micaceous rock.
2. Altered felsite rock, which becomes, at times, schistose and is then the same as that known as "quartz-schiefer" by the German petrologists. This seems to form the fundamental rock in places, while in others it is intrusive in the micaceous rock, thus proving the latter to be the older.
3. Capping the hills is a gneissose basic rock and hornblende-schist.

In this complex occur the following intrusions :—

1. Veins and dykes of a felsite rock.
2. Reddish granite rock.
3. Granite with large felspars (5 × 2·5 cent.).
4. Dykes of a much decomposed doleritic rock running S.W.–N.E., and younger than all the others.

This complex has been entirely covered at one time by the sandstones of Carboniferous age, and as a consequence presents a flat surface with no crests standing out to relieve the monotony. It has evidently been produced by the erosion which took place as it subsided under the water prior to the deposition of the sandstones.

The group of true gneisses and schists occupies a much larger area.

On its southern side it abuts against Gebel Madsûs and Mareia, continuing from there along either side of Wadi Ferân; its western edge flanks the range of Serbâl; while its eastern boundary skirts the base of Gebel Goze and Banât, and passing on into Wadi Rahaba and Rummâna keeps all the while more or less parallel to Ferân. This rock extends down Ferân as far as the sedimentary area, where it is cut off by the great fault which follows the line of the hills. From this point it runs parallel with the fault until near Wadi Sidri, where it gives place to the pink granite, passes round to the east, and occupying the country on either side of Wadi Um Agraf (the continuation of Sidri), eventually disappears underneath the sandstones, but always shews wherever a wadi has cut through the latter. It is last seen round the mouth of Wadi Baba, but it undoubtedly persists under the Carboniferous rocks for a good distance. As has been stated in the account of the dyke-rocks, this rock is very much cut up by dykes in Wadi Ferân. In its characters this rock is very constant all over the area. At the head of Wadi Hebrân, where it was first encountered, it consisted of a fine biotite-gneiss interlaminated with mica-schist, and well-banded quartzose veins also running through it. In places there is a tendency to pass into mica-schist by the increase of mica. The inclination of the shear-plane is towards the south. Associated with this gneiss in Gebel Matakh el Barûd is a garnetiferous rock of siliceous appearance; but a crystalline limestone is also mixed up with it. There must have been some powerful force acting here, for some excellent examples of crumpling are seen, the axes of the folds being in a vertical plane. In one place a fold was seen in the form of a horse shoe only 2 metres across, and with much sharper folds inside it. In Wadi Ferân the gneiss is more normal, and the bands of mica-schist are not much in evidence. Below the Oasis of Ferân, in one of the small wadis which come from the sedimentary area, some fine examples of crumpling were seen, the black micaceous bands standing out from those of white felspar. In the lower half of the Wadi Um Agraf the gneiss returns to the Hebrân type—a mixture of fine-grained biotite-gneiss and schist. Further up the wadi the coarser variety comes in, and continues until the sandstone country is reached. In Wadi Baba and its tributaries, the gneiss is a dark-grey fine-grained rock, approaching a schist in character.

Origin of the Gneiss.—On this side of the peninsula there does not seem to be any doubt as to the origin of this rock. ' It was pointed out in the description of the grey granite that, at the mouth of Wadi

el Sheikh, this rock first of all became gneissose, and very shortly afterwards passed into a true gneiss. This has been seen at various places, the two rocks shading into each other. It thus seems indubitable that this rock is simply the result of the deformation of the grey granite. The cause of this is probably to be found in the eruption and intrusion of the granite mass of Serbâl. A glance at the map shows the gneiss to form a sort of fringe round the base of this mass, gradually shading off on either side into the normal grey granite.

The age of the gneiss can only be fixed within wide limits. It is known to be prior to the deposition of the Carboniferous sandstone, and subsequent to the intrusion of the pink porphyritic granite, which is also earlier than the sandstone, but is evidently subsequent to some limestones, shales, and sandstones to be described immediately, which it has metamorphosed so completely that all trace of fossils has been obliterated. As these rocks are involved in the same folds as the gneiss it follows that the gneiss belongs to the same period. All that can be said, therefore, is that the gneiss was formed in post-Archœan times and probably in the early Palæozoic period.

2. *Metamorphic limestones and schists.* — These occur mainly in one patch in Gebel Um Esnân, although they were also seen in Gebel Matakh el Barûd, associated with the gneiss above-mentioned. In the former hill it would seem that these rocks have been faulted down against the gneiss as the remains of its bedding is not very far from the horizontal. The beds seen here are crystalline limestones, altered shales and sandstone, the metamorphosing agent being the pink granite which forms the country round about. In the two former rocks, garnet is very abundant, occurring in large irregular masses, rather than in good crystals, and becoming a veritable "granat schiefer," while the sandstone shows biotite and perhaps felspar. The complete description of these rocks must wait until the thin sections, which are being prepared, have been examined. As to their age enough has been said in the previous paragraph to indicate the extent of the writer's knowledge concerning it.

It is now possible to give a tabular statement of these rocks in the order of their age, beginning with the oldest:—

1. Diorite.
2. The grey biotite-granite.
3. Biotite-gneiss and schists, together with the Metamorphic limestone and sandstone.
4. Pink porphyritic granite.

5. Coarse Red Granite.
6. Syenite and Syenite-felsite.
7. Quartz-felsite and dolerite dykes (older series N.W.–S.E.); relations between those two uncertain, but reasoning from analogy the basic is the younger.
8. Dolerite dykes N.W.–S.E., dolerite-necks and the lavas of the Carboniferous period.
9. Dolerite dykes in the Cretaceous rocks.
10. Lavas younger than the Cretaceous in Wadi Tayiba.

The following is probably somewhat like the sequence of events in this district. During Archæan times the grey granite and diorite were intruded into old Archæan rocks, which were subsequently removed by denudation to form the later sandstone. Later on, sandstones and limestones were deposited on the exposed surface of the granite, to what extent is not known. Following this came a disturbance which developed into a thrust in a north-easterly direction, in all probability being caused by the intrusion of the pink porphyritic granite along the line of the present Serbâl range, shearing the grey granite and setting up gneissose structure. This movement continued until Serbâl and other ranges, had reached their full height, the coarse red granite having pushed all the others up into a big dome, which was subsequently denuded leaving them as they now stand. In the wake of this came other movements, causing numerous fractures S.E.–N.W., and N.E.–S.W., which were injected by quartz-felsite and dolerite dykes, many of these having been opened previously as they contain compound dykes of granite and one of these other rocks. After a time, during which denudation was very active, and the district was slowly sinking under the sea, the deposition of the Carboniferous took place, towards the close of which period the volcanic vents above described were opened, and the lavas above-mentioned were poured out, certain new fissures being formed and injected with dolerite. After this a period of quiescence and steady deposition took place until Eocene times, when a few cracks in the secondary rocks were injected. The last occurrence is the outpouring of the lava in Wadi Tayiba. This took place, as has already been stated, in Oligocene times, the lava occupying the same position as it does in the district between Cairo and Suez.

Section IX.—ECONOMIC GEOLOGY.

Granite.

Of the various products of this area, perhaps the most important is the large area of grey granite, which is suitable for statuary purposes. This is best developed in Wadis Meâr and Hebrân, although it also occurs to the south in Wadis Shiddiq and Emlaha. From the former of these localities there is no difficulty about transport, as waggons could be run on a light railway attached to a rope, the laden ones running down to the sea coast by gravity, and drawing up the empties at the same time. At El Tor the stone could be put on board boats and conveyed to Suez or Port Said, if required, the expense being in this way reduced to a minimum. A good supply of water would be easily obtained in the wadis, as the rainfall is quite sufficient to produce a constant supply if it were collected. In fact, in the winter season, running water is met with in many of the wadis.

Sand.

The next thing of importance is a pure white sandstone, very friable, and which, on account of its freedom from iron-oxide, would be very useful in glass-making. This sandstone occurs at the foot and in the cliff of Gebel Dhalâl, where there is about 200 metres of good stone. The only draw-back to its use is the distance of transport, although a fairly good road could be made with little difficulty to the sea.

Iron and manganese ores.

Perhaps as valuable as the foregoing are the iron and manganese ores of this district. These occur in the Carboniferous formation at the base of the limestone at its junction with the sandstone. They evidently occur more or less in "pockets," but as far as was seen they exist everywhere where the limestone is exposed, and vary in thickness from 0·6 to 1·3 metres. In different places the ore varies in composition, sometimes being pure hæmatite, sometimes an admixture of that and the oxides of manganese, while in others it is pure manganese oxides. The three places where it was examined were Wadi Malha, Wadi Nasb, and at an old mine in Wadi Halliq. In the former locality the two ores lie side by side, as if they had segregated so, being more or less distinct from each other, but on their junction being intimately mixed. The same is true of the second locality, but in addition there is a fair quantity of earthy manganese-ore (wad). In the third locality the hæmatite is more abundant, the limestone being impregnated with it near its base, while nodules of pure ore weighing from 25 to 50 kilos. are frequent.

The following analyses made by A. Lucas, Chemist to the Survey Department, give the general composition of these ores:

WADI MALHA.

Number	Fe_2O_3 %	Fe %	MnO %	MnO_2 %	Mn %
3946	46.96	32.87	..	..	..
3911	3.74	2.62	15.21	71.59	57.00
		WADI HALLIQ			
3970	25.34	17.74	..	38.19	24.12
3970 A	..	..	41.03	45.50	60.48
3970 B	20.14	14.31	..	39.95	25.23
3970 C	..	..	..	71.41	45.10
3971	27.60	19.32	14.60	40.81	37.03
3971 A	32.10	22.47	..	..	..
4135	2.32	1.62	..	30.33	19.16
4136	34.24	23.97	..	29.52	18.66
5000	69.34	48.54	..	3.06	1.94
5001	16.90	11.83	32.87	18.56	37.18
5002	98.24	68.77	..	..	..
5003	93.69	65.58	..	..	..
5004	73.62	51.53	..	9.58	6.05
5005	38.80	27.16	14.72	24.10	26.64
5006	25.86	18.10	..	..	..

In all these specimens the gangue was practically all silica; traces of lime were found in all of them, while two of them contained as much as 16% and 18%; nearly all of them were hydrated, although in some only a trace of water was found. This water may be either from the manganese compounds, many of which contain water, or from the brown ferric oxide which is nearly always associated with the hæmatite, the latter gradually passing into the former by hydration.

The percentages of iron and manganese given in the above table show at a glance whether the ore is a rich one and worth exploiting. The whole of the samples taken from Wadi Halliq were collected from an old mine which had been opened there presumably for the working of copper ores, most of the specimens being obtained from the rubble heap at its mouth. Specimen No. 3,971 A is a red ochre or raddle; while Nos. 3,971 and 3,970 are black, earthy, amorphous substances like wad. An almost pure hæmatite is No. 5,002, while No. 5,003 follows closely on it. Of the manganese ores No. 3,970 A is a good example, being a very fair specimen of psilomelane, while 3,911 and 3,970 C also compare very favourably. The others are only varying mixtures of hæmatite and the manganese oxides, which owe their richness or

poorness to the quantity of gangue, and impurities with which they may be mixed. These may be useful in the production of manganese-steel.

The position of these ores is perhaps against their being profitably worked, situated as they are some little distance from the sea-coast where no fuel is obtainable. The other alternative of bringing the ore to the sea-coast and treating it there, or shipping it elsewhere, is therefore the least expensive, although the cost of transport might even then be prohibitive. The actual mining of the ore would not present much difficulty as the underlying rock is not hard and difficult to pierce.

Since writing the above, a copy of a paper on "The Manganese Deposits of Bahia and Minas, Brazil," by professor J.C. Branner * has been received.

The difficulties of working the last-named deposits are very similar to those in Sinai. No fuel is available, and the whole ore has to be dug out and transported by rail to Rio, whence it is shipped in great part to the United States. The manganese deposits of Minas lie near the railway about 500 kilometres north of Rio, the cost of transport for all that distance has therefore to be borne by the mining company. This it seems able to do After reading this paper, it seems as though the deposits in Sinai might also be worked at a profit. Appended is a table showing the percentage of metallic manganese in the different samples from various mines in Minas, with a column of the composition of the Sinai ores for comparison.

	Minas Mn %	Sinai Mn %
Sample from kilom. 499 Central Brazil Railway	54.96	57.00
		60.48
„ „ „ 500 „ „ „	50.46	45.10
„ „ „ 503 „ „ „	50.44	37.03
„ „ Itabira kil. 524 „ „ „	31.75	37.18
„ „ Vigia „ 500 „ „ „	55.40	26.64
	29.8	
„ „ Quelez Lafayette Station kil. 463...	36.7	25.23
	60.1	
„ „ Rodrigo Silva kil. 521.....	62.0	24.12
	60.9	
„ „ „ „ „ „	49.7	
	51.4	
„ „ Hargreaves kil. 515	48.96	
	57.40	

* American Instit. of Mining Engineers, Sept., 1899.

There were other samples from Minas containing from 40% to 60% Mn.

A glance at the columns of the latter table shows that, taken as a whole, the Sinai ores are of a poorer quality, but taking into consideration their much closer proximity to the sea, there seems no reason to doubt that they might be worked at a profit, provided that the deposits turned out as rich as they appear to be by the analysis of the samples.

Copper. Of the ores of this mineral, only traces have been found along the joints of the limestone. In the majority of instances these have been removed by the old miners who used Wadi Nasb as a centre of this industry. The surface of the limestone plateau has been searched diligently by them, and even the poorest veins have been worked out. The ore was mainly the blue and green carbonate, portions of which were found at various old workings.

Holland † suggests that probably all the material for the manufacture of glazes was obtained from Sinai.

Slag. The only other ore found in this district was obtained from a heap of slag on Gebel Safariat, where it had evidently been smelted for copper, judging by the meagre traces of that mineral seen in it. A piece of it on analysis gave 23·46% of ferric oxide, while there was also a small amount of manganese likewise present. In the pounded up mineral were found several small pieces of metallic copper.

Bone-bed. In this hill there occurs the only bone-bed known in Sinai about 0·3 metres thick. In character it is very similar to that found on the west side of the Gulf of Suez, and contains numerous teeth. An analysis yielded the following result:

Phosphoric acid ($P_2 O_5$) 24·63% = tricalcic phosphate ($Ca_3 P_2 O_8$) 53·77%.

This analysis shows this deposit to be better than those occurring on the west side of the Gulf of Suez, the highest percentage of tricalcic phosphate being 50·78.

Coprolites.—In Gebel Hoshera a few nodules of a phosphatic nature, resembling coprolites, are scattered about in the yellow sandy beds which occur near its base. They are, however, not in sufficient quantity to make them of economic importance. An analysis of a sample yielded 12·94% tricalcic phosphate.

Hydrocarbons.—These occur all through the Cretaceous limestone,

* Op. cit.
† Op. cit.

their presence being discovered by the different dykes and veins which cut this rock, but they are in such very small quantities that nothing can be done with them. The only place where they seemed to be in quantity was at the mouth of Wadi el Araba where the white sandstone of the Nubian series is rendered absolutely black by impregnation with them. Even here, however, they were not in any quantity, the total loss on ignition being only 8·69%.

Celestine.—In the Beach Deposits of Wadi Amara on the Suez Road, there occurs veins of a heavy, brittle, crystalline, colourless mineral, which evidently belonged to the isomorphic group of rhombic sulphates. On being analysed it proved to be an almost pure sample of celestine (strontium sulphate) containing only 3·88% of impurities which are made up as follows:—

Water, carbon dioxide, and organic matter	2.00
Silica	0.69
Iron and Aluminium oxides	0.92
Lime	trace
	3.88

Turquoises.—These stones are known to occur at two places, viz., Gebel Maghara and Serabit el Khâdim, but in the latter place the quality is so poor that the work has been abandoned, although the former place is still exploited. The mines in Gebel Maghara have been worked by the ancient Egyptians since the beginning of the 4th Dynasty up to the time of Rameses II; while those of Serabît el Khadîm were exploited up to the time of the 20th Dynasty. * Nothing is known further as to their history until a Major Macdonald in the middle of last century settled at Maghara and took up the working of the mines, but he subsequently abandoned them as they did not pay expenses.

When visited in the early part of 1899, these mines were being worked by the Bedawin, nearly every man in the district having spent a certain time there at one period or other of his life. From information supplied by the Bedawin, it seemed to be the custom for the young men about to marry, to go to the mines and try their fortune, and if they were successful it enabled them to pay the necessary dowry for their wives.

In Gebel Maghara these mines extend over an area measuring 1·6 by 0·9 kilometres. This district is one in which considerable movement has taken place, faulting and folding being seen on all sides, and it is

* "Baedeker's Lower Egypt," 1885, pp. 491-93 and 523.

to this that the present restricted working area is perhaps due. To the north of the area the turquoise-bearing bed is thrown down beneath the surface by an east-and-west fault, while to the west the beds dip suddenly at a high angle, and run to earth in a very short distance, in this way confining the working area within very narrow limits.

The turquoises occur in a purplish-grey bed of sandstone which is of Carboniferous age. The master-joints of the rock run north and south, and east and west; but minor cracks cross the rock in every direction and owe their origin to the earth movements. Threading the bed in question are numerous streaks of an ochreous, friable sand, which also forms "pockets" in the solid rock, and it is in this sand that the gems are looked for, and from it those of the best quality are obtained. Thin veins of turquoise of very inferior quality also line the sides of the joints. From men who have worked in the mines, it was learned that the stones lie very unequally; men may go on working for days without finding anything, when shortly after a "pocket" is struck in which some very good stones are found.

The main workings occur in Wadi Qenaia, but a few also occur in Wadis Qena and Sidri. The best gems are, however, obtained from the mines in the first-named valley. The different mines are known to the Bedawin by distinctive names. The following are the names of the present workings:—

1. Hagaga.
2. Yahudia.
3. El Shebb.
4. Hadêd.
5. Um Hassan.
6. Sufra.

Under the first name are four mines which are worked, the most southerly having been only recently started; the two middle ones are the oldest of the series, having a small gallery driven into the rock at the end of which is a vertical shaft, down which a guide went with a candle, and reported that no galleries went off from it. This may not be true, however, as the people block up the entrances so cunningly that it is difficult to detect them. In the fourth there was a shaft similar to the other two. The second on the list is said to be the most valuable, yielding stones of the best colour. It had a wide and high entrance-chamber, from which two galleries branched off into the hill. El Shebb has only been recently started as the face of the cliff is only being worked. The other three are being worked still, but they yield stones of inferior quality. From all sides there seems to a concensus

of opinion among the Bedawin that the richest mines are those in the neighbourhood of Yahudia.

According to Bauerman * the turquoises occur about 250 feet above the bed of the wadi, in two beds about 15 to 20 feet apart. The most of the stones, however, are in the upper bed. The stones lie along the joint-planes lining the faces, and also occur in the centre of small red marly or ochreous nodules near the joints. In the latter places the stones of the better colour are found, those lining the joints being of poor quality. The miners evidently followed the joints, working out the rock on either side. This was then broken small and passed through a half-inch sieve, the coarser parts being brought to the mouth of the cave, and examined in daylight. The likely-looking pieces were then rubbed on a piece of coarse grit in order to see whether they contained turquoises or not; if any colour is apparent the stone is thought to be worth keeping.

Speaking of the mining tools used, this author says that flint chisels and stone hammers were used. In searching one of the smaller caves, several chips of stone hammers were found, as well as pieces of wood, some partially carbonised. These he considered to be parts of cylindrical blocks which served as mountings for the flint chisels used by the ancient miners.

Origin of the turquoise.—It has been stated by Holland that the turquoise occurs in cracks in a porphyry and in the sandstone, but this has not been confirmed by the present observations; no turquoises are seen near the basalt which caps the hill, the stones being found about 60 metres lower down. From what was seen and learnt from the guides it seems that the turquoises have been formed by percolating water and in no way owe their origin to igneous action. This agrees with the experimental results obtained in the artificial production of these gems. It is found that, if freshly precipitated phosphate of alumina be coloured by a solution of blue chloride of copper, dried at a gentle heat, and then subjected to enormous pressure, a gem is obtained which is little inferior both in colour and polish to the natural stone. In this district the conditions necessary for the production of these stones have been present at some former time, as is evidenced by the presence of the previously-mentioned folds and faults.

It is difficult to form any opinion as to whether these mines would yield a sufficient return for the labour spent in working them, as the

* Op. cit.

people are very averse to giving any information about the quantity and quality of the stones they obtain. It seems certain that the Bedawin make sufficient out of them to allow of them buying gunpowder and using it freely, while the people in the vicinity seem to be fairly prosperous, and able to buy grain in large quantities, and store it for use in the summer. This is unusual among Bedawin who are, in general, extremely poor. There seems to be a regular trade in turquoises carried on between merchants at Ayun Musa and the Bedawin, who barter the stones for gunpowder and other stores.

The way in which the mines are worked is very slovenly, all the rubble being thrown back behind the workers thus blocking up the exit more or less. If the people can make it pay working in this careless manner it seems that it ought to be made a fairly profitable concern with improved methods of working and economy of labour. To develop these mines it would be necessary to spend some money in making proper galleries from which to work the turquoise to advantage, and for this a certain amount of capital will be required.

Section X.—DENUDATION AND WEATHERING.

This subject has been treated at some length in a previous report (*) in which the agents at work in a comparatively rainless country have been set forth and discussed. These agents are equally potent in the district under description, but there are others peculiar to it, which are of comparatively little importance in a country in which desert conditions prevail. These are as follows:—

1. Rainstorms.
2. Frost and snow.
3. Action of moisture, containing carbon dioxide.

In addition to these which are peculiar to this district of Egypt, the action of wind and sand is particularly well seen. Here, as in the other parts of Egypt known to the writer, it is the wind from the south, south-west, and south-east (especially from the two former directions) which causes the sand to travel. There is however an exception in the case of the coast-plain to the north of Wadi Gharandel, where the north-east wind which sweeps down from Gebel el Ti often brings clouds of dust along with it.

(*) "Topog. and Geol. of Eastern Desert of Egypt, Central Portion," by T. Barron and W. F. Hume. Cairo, 1902.

1. *Rainstorms.*—Taking the agents in their order, the first to be described is the effect of the rainstorms. No one who has spent any time amongst the Bedawin of Sinai can have failed to be struck by the great care which these people take in choosing a camping place in the wadis. Nothing will induce them to camp in the bed of the wadi, even when the weather appears settled and the sky clear overhead, long experience having taught them how uncertain these appearances are, and how suddenly the storms break over the hills. In a few hours the peaceful appearance of the scene may be changed, and the dry valleys transformed into roaring torrents whose resistless might carries everything before it. Should any one have been foolhardy enough to encamp in the bed of the wadi he runs a good chance of being overwhelmed and carried away. Some idea of the resistless character of these storms may be obtained from an inspection of some of the wadi-beds after a storm. Deep cuts, some of them over 2 metres deep, have been made in the valley-floor, while boulders of enormous size have been dug out and carried down the wadi. On the sides of the wadis, too, marks may be seen about 8 metres above ground level indicating the height to which the water has risen, while uprooted bushes testify to the force of the current. A further witness to the great transporting power of the torrents is seen in the big deposits of boulders which lie like a fan at the mouths of some of the main wadis e.g. Wadi Hebrân and Emlaha.

2. *Frost and snow.*—These agents are only seen at work in the higher altitudes near the watershed, e.g., the upper part of Wadi el Sheikh and its tributary Wadi el Dêr, the granite massif of Gebel Musa and the neighbouring peaks, the high dolerite hill of Gebel Moreia, or the rugged range of Serbâl which overlooks the plain of El Qâ. On the north side of these hills in the winter months, hoar-frost can be seen throughout the day, the temperature never rising sufficiently to melt it. This condition continues for several days at a time, and there can be little doubt that the frost plays a great part in the disintegration of the rocks of these hills. On the surface of the gentler slopes a thin coating of disintegrated rock is seen which supports a few small plants while on the narrow ledges, and in the small nooks and cracks in the rock, a thicker deposit is seen in which grow luxuriant specimens of "Hamada" and other plants.

In the upper part of Wadi el Sheikh, during the survey carried out by the writer, temperatures up to $-9°$C. were observed, and in the wadi the frost held sway through the entire day, the water-pools being covered by a thick sheet of ice. These conditions prevailed with varying

intensity for over a month, while snow was seen lying on the highest peaks of the watershed ranges for nearly two months. It follows therefore, that as the sun's heat increased, there would be alternate thawing and freezing which would tend to fracture, and finally detach pieces of the rock which would eventually be reduced to a fine powder by the continued action of these agents. Thus in this district, the action of frost, etc., ranks as one of the most important factors in the disintegration of the rocks.

3. *Action of moisture containing carbon dioxide.*—Coming to the last agent on the list, it may be regarded as the successor to the frost and snow, continuing and completing the work which the latter had begun. At the close of the winter the disintegrated rock acts as a covering to the surface of the rock, checking evaporation, and at the same time on account of its state of fine division acting as a sponge to absorb the dews which always form during the night in the higher regions. The seeds of plants of various kinds are borne by the wind and finally find a resting place in it, eventually germinating, flowering, and dying. In the autumn the annual rains fall, and as the temperature is sufficiently high to promote the rapid decomposition of the leaves and other parts of the plant into their ultimate components of carbonic acid gas and water, these are carried down to the surface of the rock and carry on the work of decomposition which the frost had commenced. In process of time the rock becomes decomposed for some distance from the surface, and the soil and loosened particles are carried off by the rain and deposited on the gentler slopes of the foothills and smaller wadis, eventually producing a soil of depth sufficient to carry fruit-trees from which the Bedawin annually obtain a crop of very fair quality, if the locust has not stripped the trees in early summer.

On the lower plateaux, where the slope is very small indeed, the disintegration of the rocks proceeds much more rapidly, especially where the country-rock is much cut up by basic dykes and intrusions. These yield much more rapidly to the weathering agents than the more acid country-rock and become reduced below the general level, forming a series of trenches towards which the rains naturally gravitate, thus hastening their decay even more rapidly. In numerous instances the gullies which seam the sides of the hills can be shown to be formed along the course of one of these dykes.

In the districts, too, where a basic gneiss forms the predominant rock of the district, the work of this agent it seen to great advantage. This rock, on account of its physical character, lends itself to rapid weathering,

its shear-planes allow of an easy passage of the moisture, while its constituent minerals having undergone deformation by the enormous force brought to bear on them, are in the most favourable condition for rapid disintegration by the agent under consideration.

The observed facts bear this out, for on the flanks of these hills quite a fair soil has formed, which in the spring-time is covered by a coat of verdure which furnishes abundant food to the large flocks of sheep and goats kept by the Bedawin. In the district nearer the sea-level, owing to the small rainfall and more seldom precipitation of dew, the action of this agent is practically nil, and insolation, change of temperature, etc., perform the work of disintegration.

In connection with this subject a paper published by J.G. Goodchild* may be noticed. In it the author, in order to establish the point in his paper, has selected the Sinai Peninsula as an example on which to base his deductions. He states that wadis in all cases are the result of running water, a statement which the writer cannot admit, as numerous instances are known where they are the product of faults, subsequently used as a channel of drainage. It is a pity, that in selecting a typical example for his paper, the author did not choose a district of which he had personal knowledge, for, as far as can be learned from his writings he had his information from a series of photographs lent him by a friend. These, as is well known, are rather unsafe sources of information, and are capable of several interpretations according to the ideas of the different people who look at them. In these photographs the author evidently mistook the remains of the filling up of the wadis during a period of subsidence in Pleistocene times (as has been stated in the early part of this memoir), and put them down to screes. These he assumes are washed down by the thunderstorms and distributed over the wadi bed, over which dunes are later formed by the wind, they in turn, being levelled down by the torrents. He thus concludes that the wadis are being gradually filled up by the detritus. Unfortunately for the establishment of his hypothesis, evidence in its favour is entirely wanting, and instead of the heaping up of detrital materials in the wadis, numerous instances can be produced where the rocky bed of the wadi is exposed, while the throwing out of the water at different points along the drainage line testifies to the continuity of the rocky floor although it is somewhat uneven. It is only in these inequalities that any deposition has taken place and that ceases immediately the level of

* "Desert Conditions in Great Britain." Trans. of the Geol. Soc. of Glasgow, 1898, Vol. XI Pt I, p. 79 et seq.

the rocky protuberance is reached. If any deposition of detrital material takes place, it is at the mouth of the wadis where they debouch on the coastal plain, and the materials are spread out in a fan opposite each drainage line.

Although the action of sand and wind has been described at length in the Memoir on the Red Sea Hills, it is impossible to omit the mention of it here also, since there are such fine examples to be seen in this district. The plain of Debbet el Ramli owes its origin to the wearing action of the wind-borne sand, and the cliff of Gebel el Ti marks the progress of the work of attrition. At the base of this cliff lie boulders of the hard, crystalline limestone which forms the beds lying on the top, showing the result of the long continued scour of the sand. They are pitted all over, and the invisible cracks which traverse nearly every rock are brought out on the surface, their course being marked by furrows. These cracks evidently constitute planes of weakness as the rock is much more eroded where they occur. In the cliff itself, all the inequalities are planed off by the sand, and it presents the appearance of having been sand-papered down. In Gebel Dhalâl where the Nubian sandstone occupies the larger part of the cliff, this rock is worn out into hollows which are evidently eddies in a sandstorm, while the rock in general stands out in buttresses in a wonderful manner. The isolated masses of sandstone are worn and rounded off into conical hillocks which in the distance look like gigantic ant-hills. But in the centre of the plain the whole of the rock has been worn away and the ground covered with the sand piled up and held together to a certain extent by plants growing on it.

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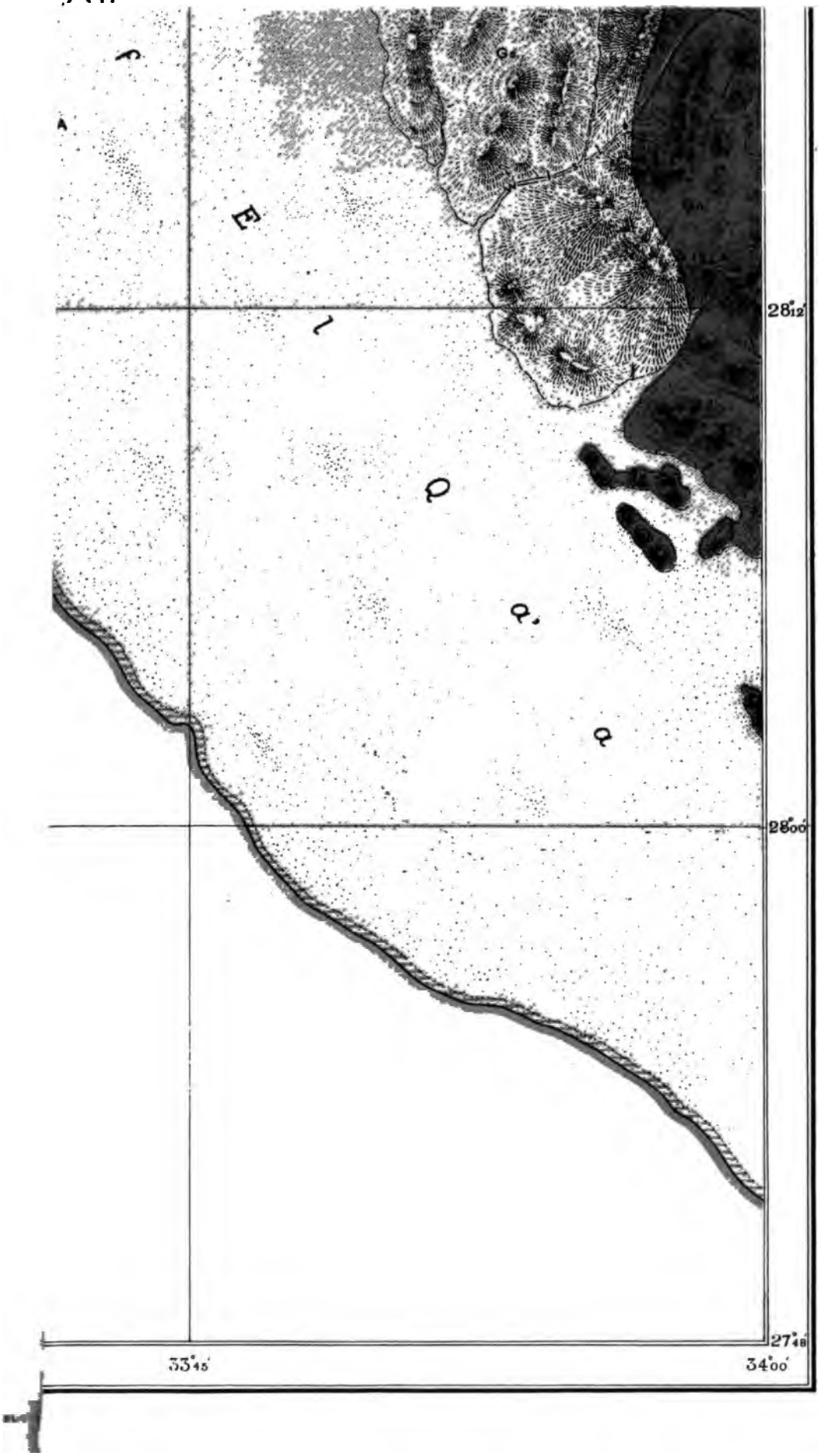

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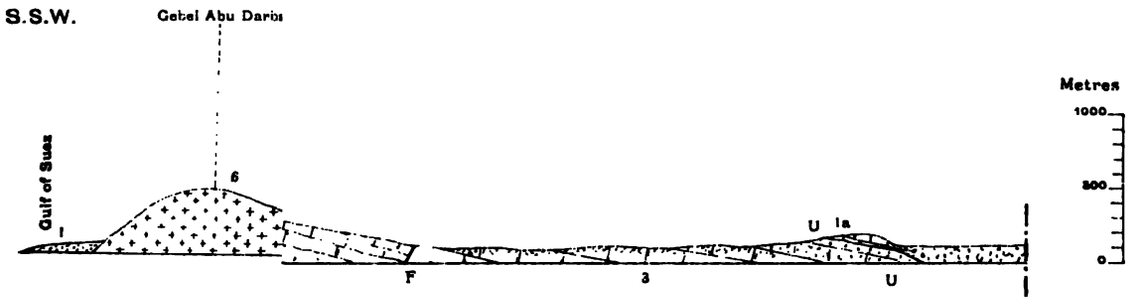

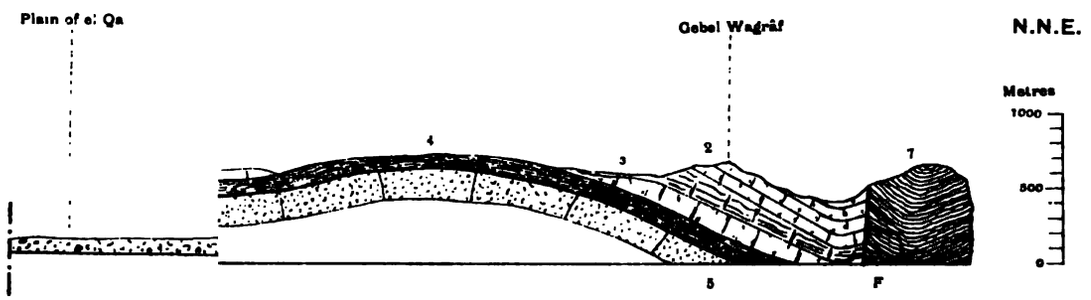

5 Nubian Sandstone.

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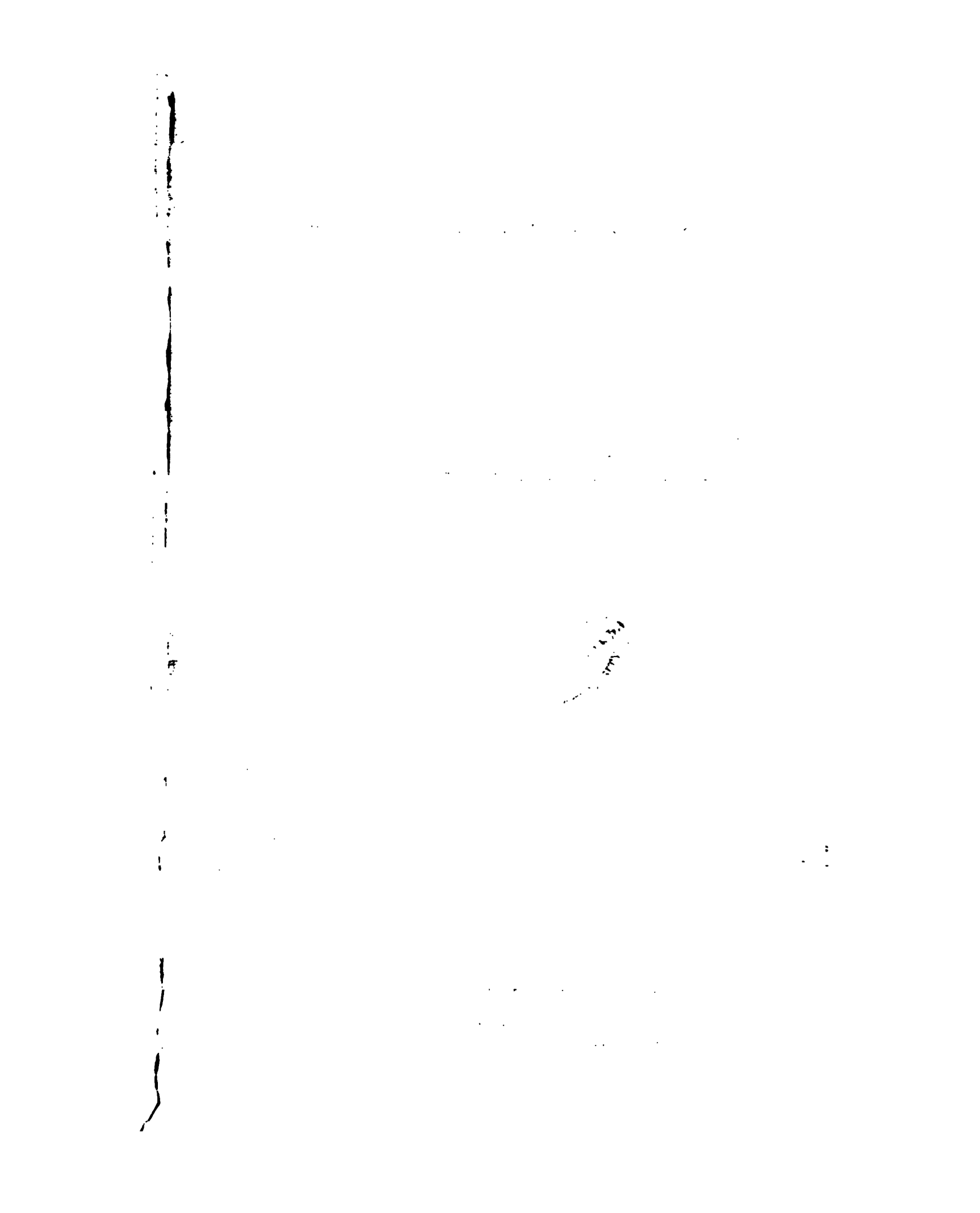

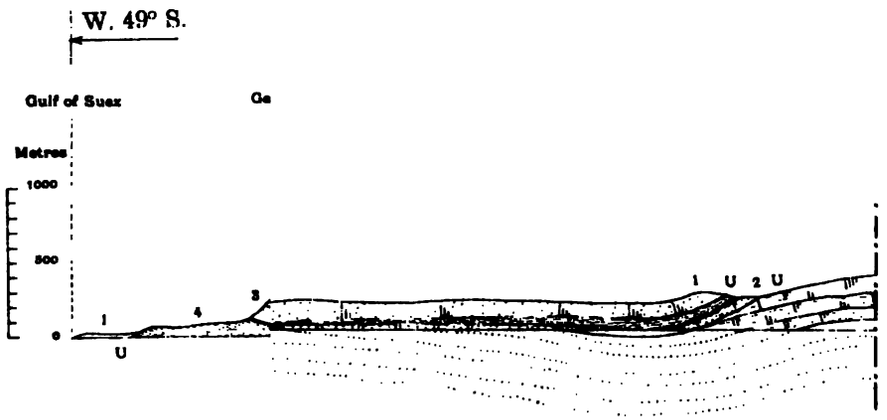

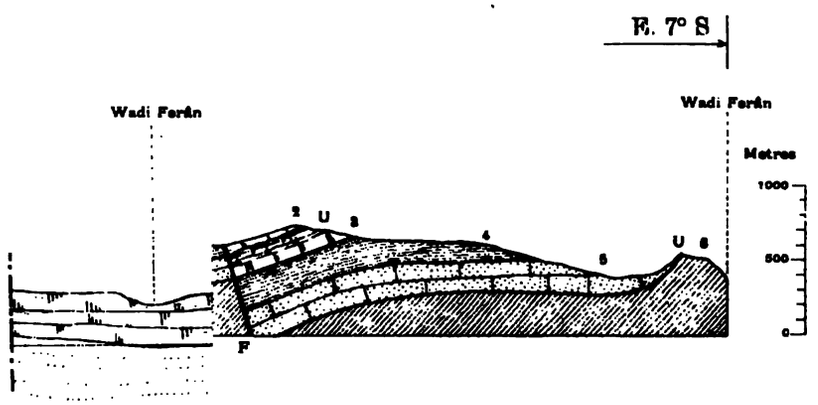

PLEISTOCENE	1.	CENOMANIAN	4. Marls, marly limestones and sands.
MIOCENE	1a		5. Nubian sandstone.
MIDDLE EOCENE	2		6 Gneiss.
CRETACEOUS SENONIAN	3.		F. Faults.
	3a		U. Unconformability.

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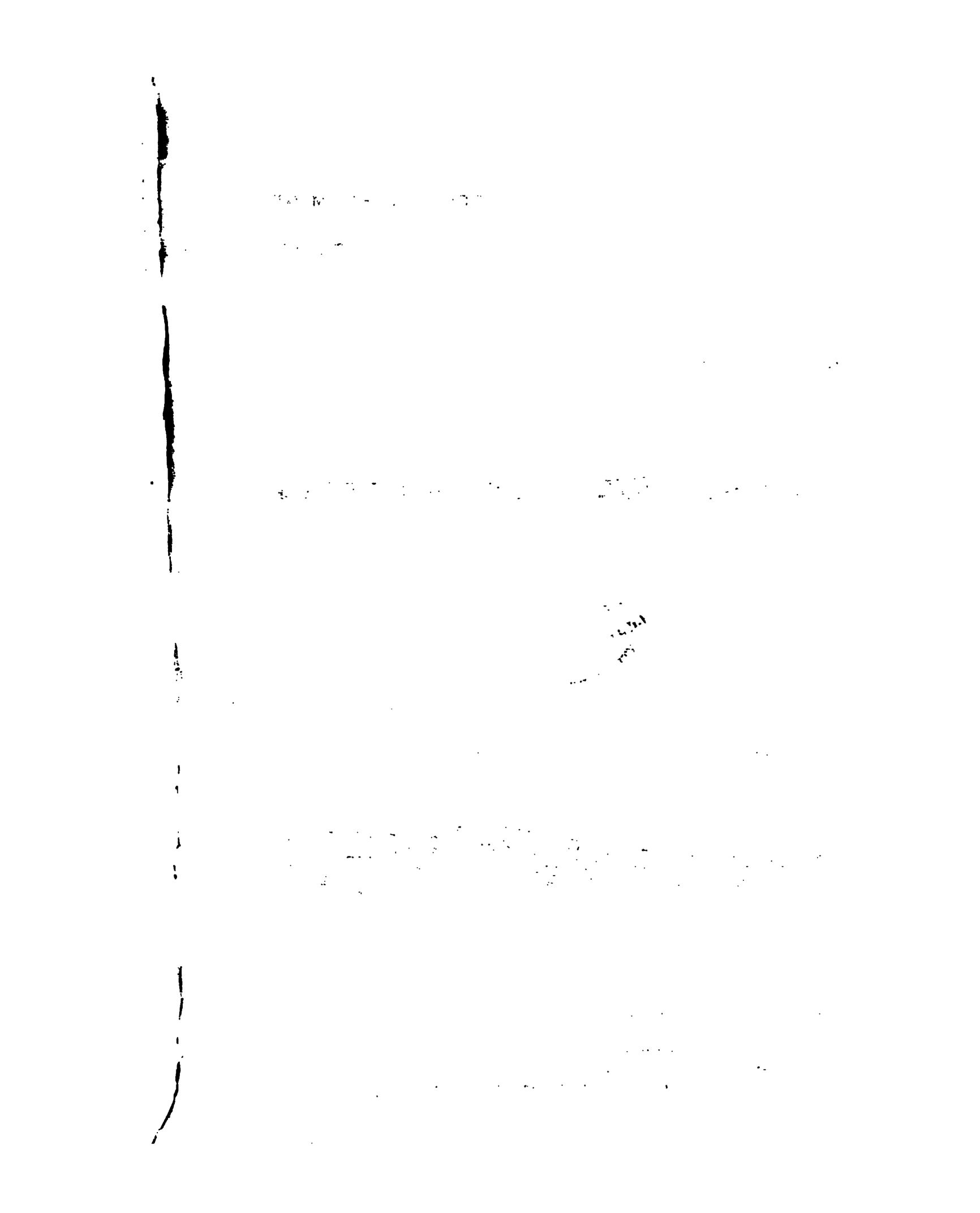

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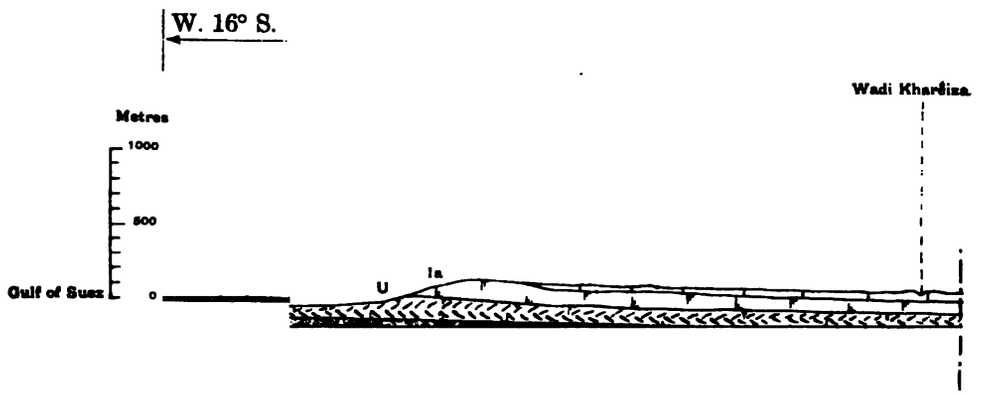

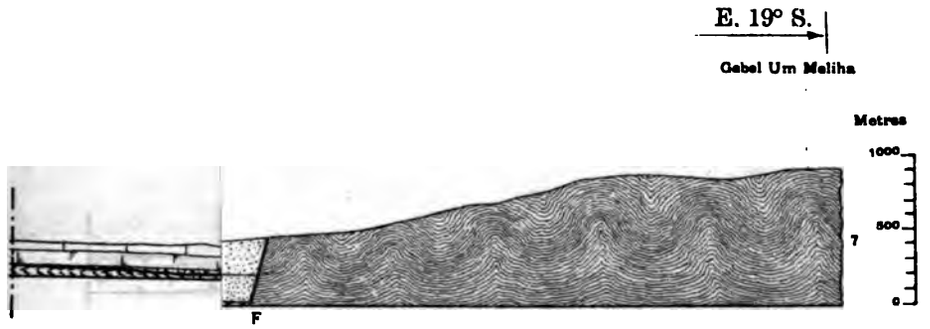

PLEISTO
MIOCENE
CRETACE

5. Sandstone.
6. Red Granite (probable extension).
7. Gneiss.
F. Faults.
U. Unconformability.

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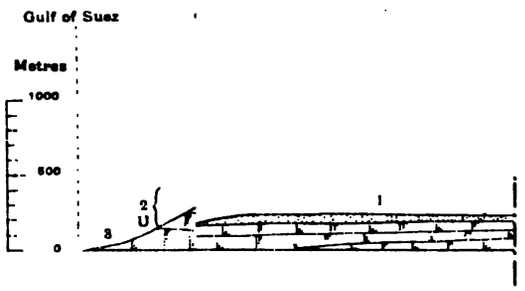
SEDI ABU QÂDA.

S.W.



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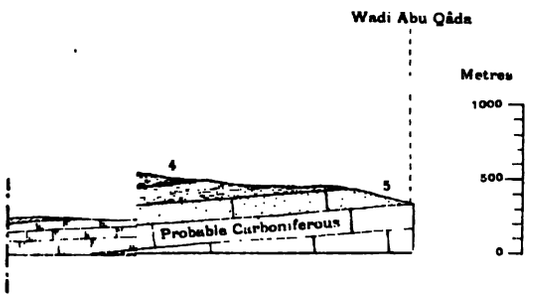

MIOCENE	1. ART)	4.	Cretaceous Marls
	2.	5.	Nubian Sandstone.
SENONIAN	3.	F.	Faults.

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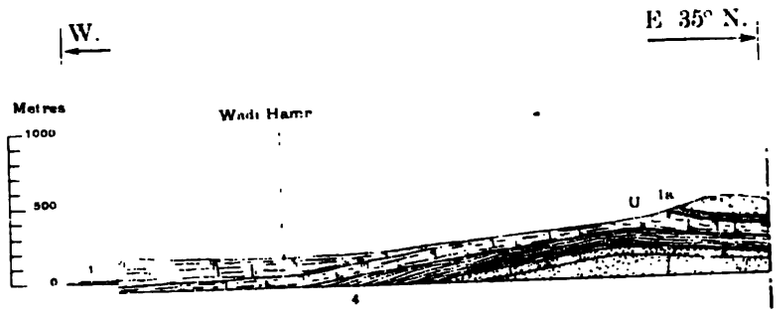

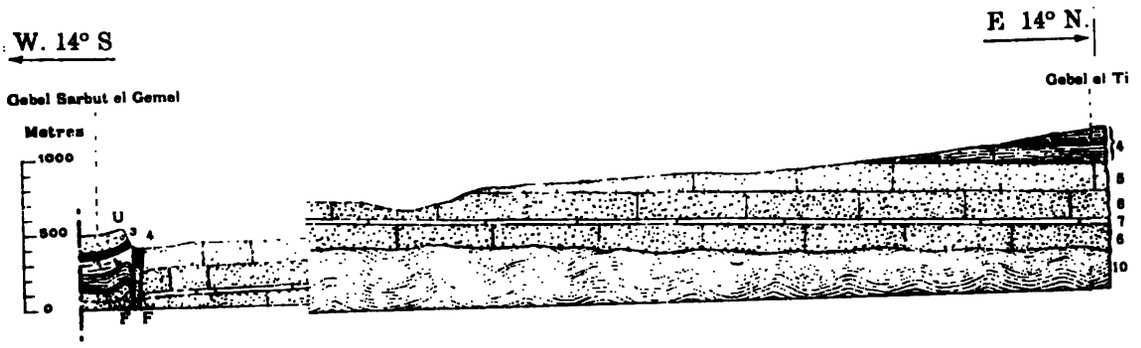

6. Carboniferous Sandstone.
7. Bed of limestone in No 6
8. Porphyrite flow, contemporaneous with No 2
9 Basic dyke in Cretaceous limestone.
10 Gneiss.
F Faults
U. Unconformability.

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J. C. Brannen

FINANCE MINISTRY

SURVEY DEPARTMENT, EGYPT.

THE

TOPOGRAPHY AND GEOLOGY

OF THE

PENINSULA OF SINAI

(SOUTH-EASTERN PORTION)

By

W. F. HUME, D.Sc. (London), A.R.S.M., F.G.S., etc.

Superintendent, Geological Survey.

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1906.

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BY

T. BARRON, A.R.C.S., F.G.S.

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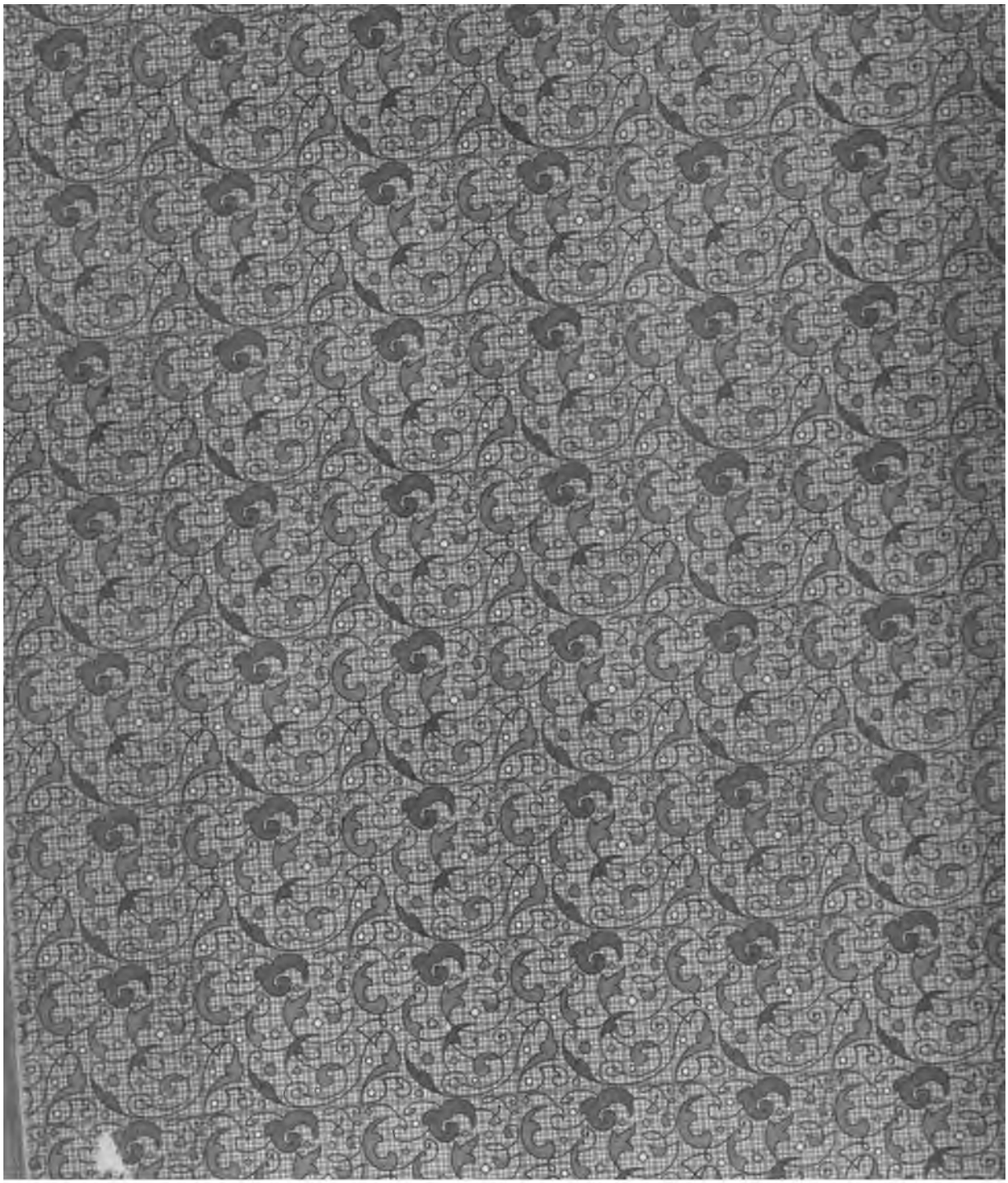

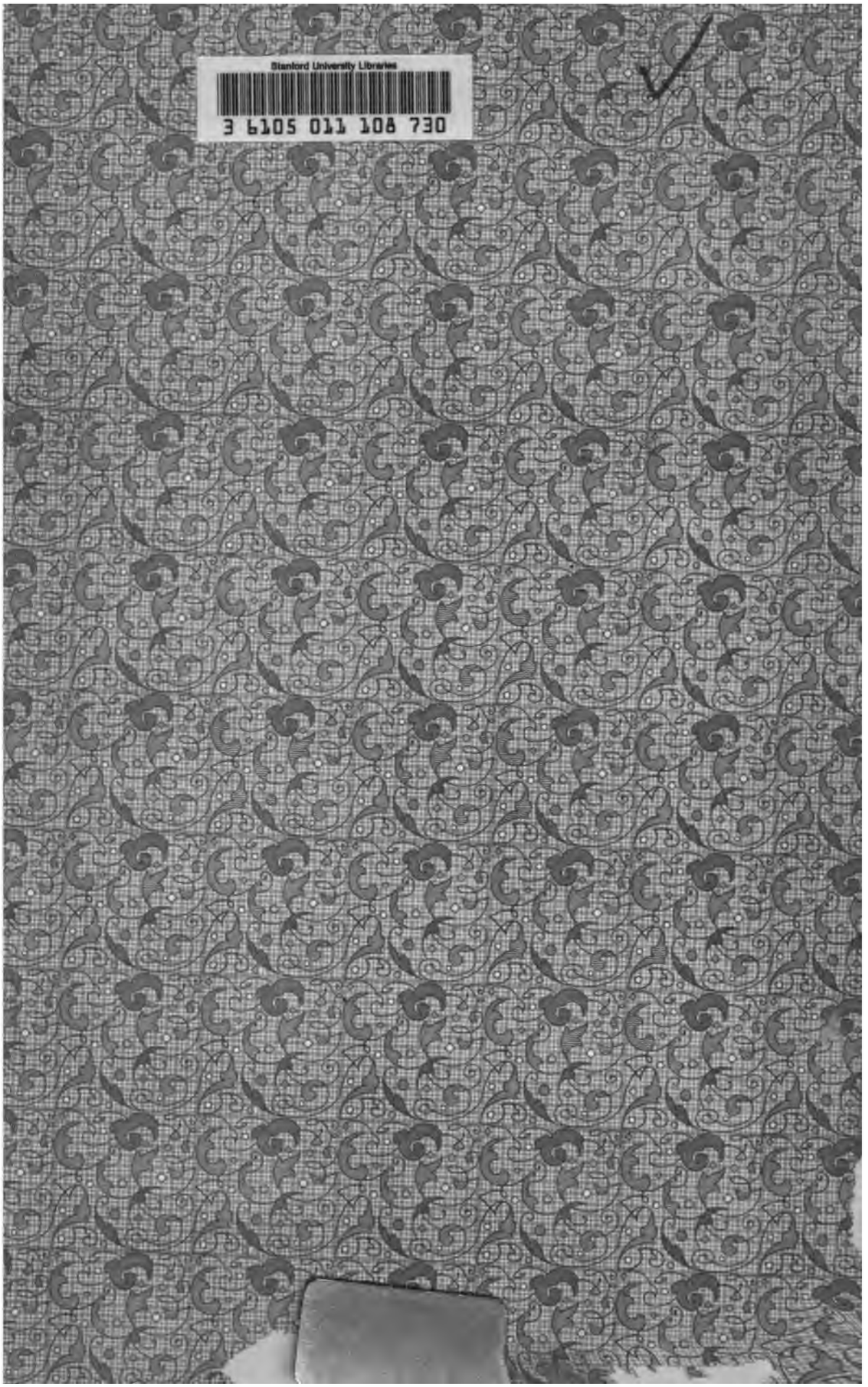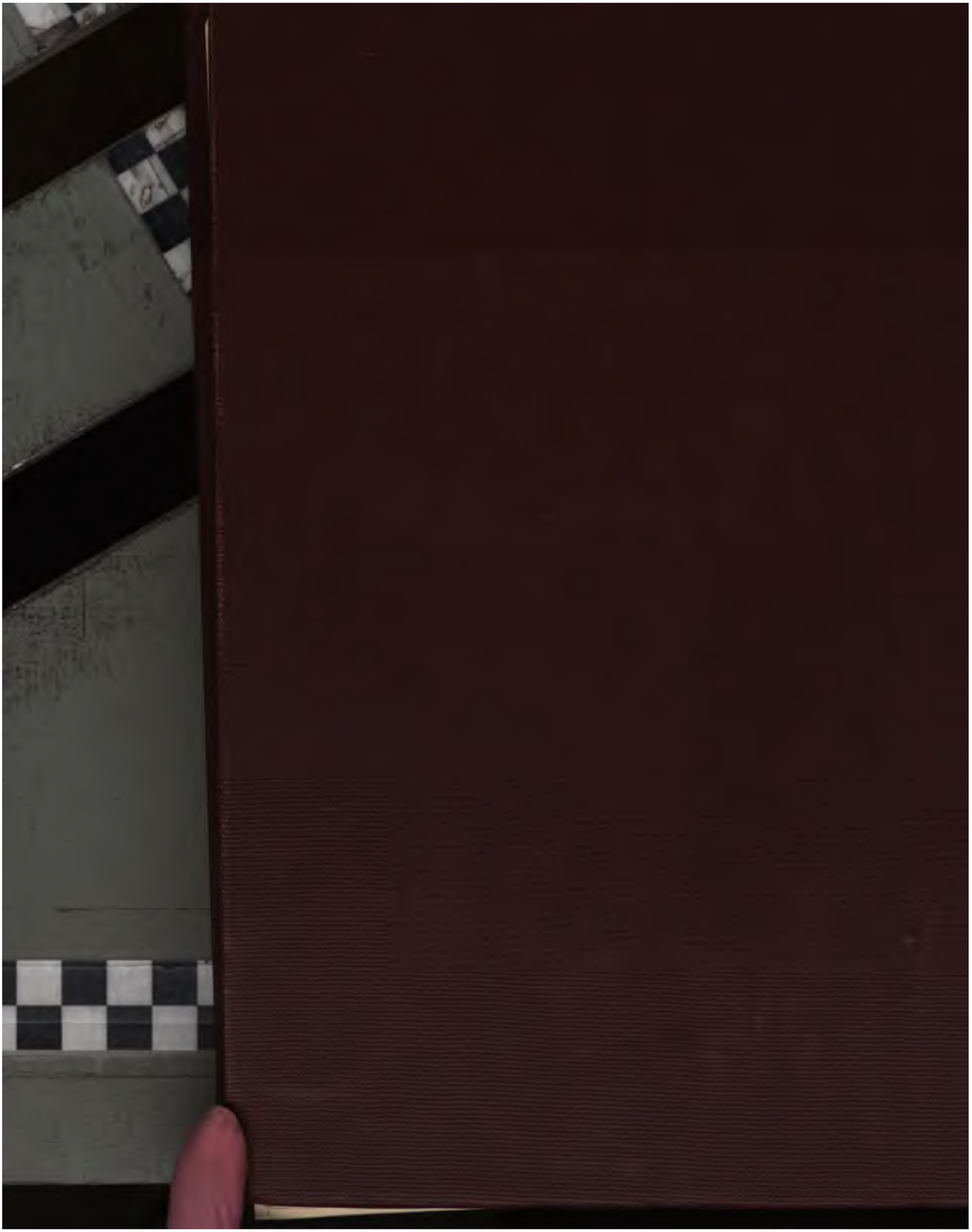
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